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Coal Preparation Plant Computer Model
Volume I. User Documentation

Battelle Columbus Labs., OH

Prepared for

Industrial Environmental Research Lab.
Research Triangle Park, NC

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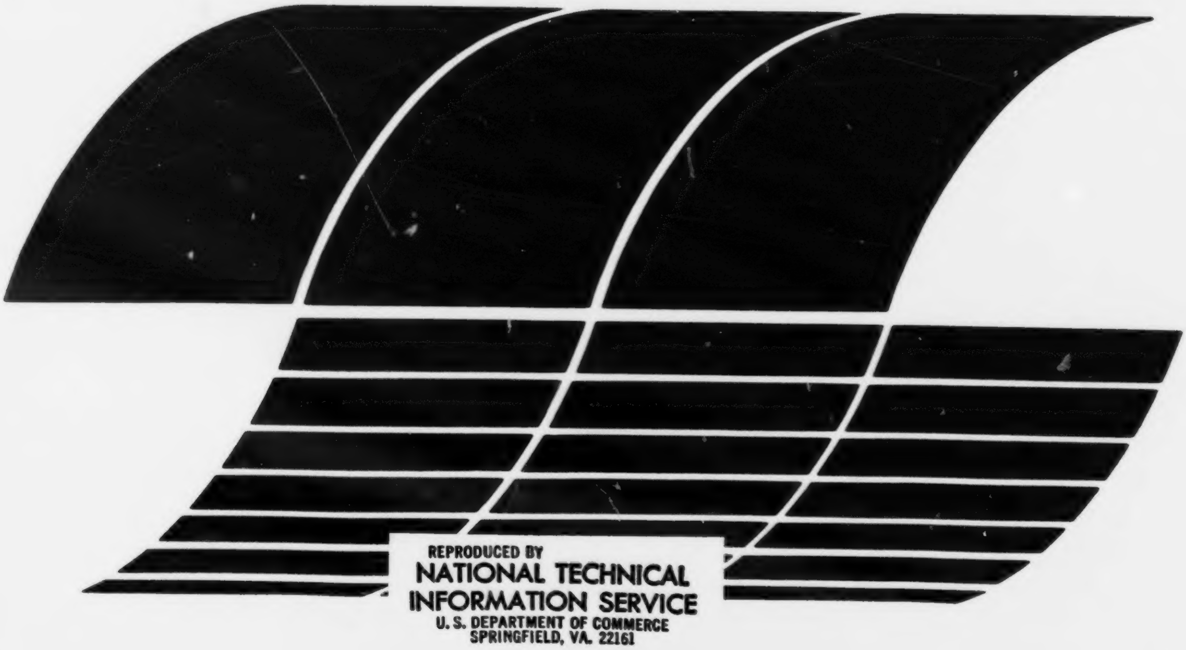
Volume I.
User Documentation

Interagency Energy/Environment R&D Program Report



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16. ABSTRACT The two-volume report describes a steady state modeling system that simulates the performance of coal preparation plants. The system was developed originally under the technical leadership of the U.S. Bureau of Mines and the sponsorship of the EPA. The modified form described in this report, written in FORTRAN, was developed by Battelle for the EPA. The original modifications made the program usable in evaluating an advanced coal cleaning facility being constructed at Homer City, PA. Subsequent changes allowed the model to be used for a wider range of performance and cost evaluations. Initial changes to the original program increased the number of process operations which could be simulated, and simplified program operation. Later modifications permitted the calculation of plant water flows and the estimation of plant costs. Volume I contains user documentation, and Volume II provides process documentation. Volume I describes: the manner in which coal flows are represented, the mathematical approach of the various unit operations, the cost evaluation approach, preparation of the input, and interpretation of the output (the last two in terms of an example). Program documentation begins in Volume II with a discussion of basic documentation principles, followed by presentation of each routine and common block in terms of these principles.

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Coal		Stationary Sources	08G	
Coal Preparation		Coal Cleaning	08I	
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Coal Preparation Plant Computer Model:
Volume I.
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by

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1-A

FOREWORD

Many elements and chemical compounds are known to be toxic to man and other biological species. But our knowledge concerning the levels and conditions under which these substances are toxic is extremely limited. Further, little is known concerning the emission of these pollutants from industrial processes and the mechanism by which they are transported, transformed, dispersed, or accumulated in our environment.

Portions of the Federal Clean Air Act, the Resource Conservation Recovery Act, and the Federal Water Pollution Control Act require the U.S. Environmental Protection Agency (EPA) to identify and regulate hazardous or toxic substances which result from man's industrial activities. Industrial pollutants are often identified only after harmful health or ecological effects are noted. Remedial actions are costly, the damage to human and other biological populations is often irreversible, and the persistence of some environmental contaminants may endanger future populations.

EPA's Office of Research and Development is responsible for health and ecological research, studies concerning the transportation and fate of pollutants, and the development of technologies for controlling industrial pollutants. As a part of this office, the Industrial Environmental Research Laboratory, which is responsible for development of pollution control technology, conducts a large environmental assessment program. The primary objectives of this program are:

- The development of information on the quantities of toxic pollutants emitted from various industrial processes--information needed to prioritize health and ecological research efforts.
- The identification of industrial pollutant emissions which pose a clearly evident health or ecological risk and which should be regulated.
- The evaluation and development of technologies for controlling pollution from these toxic substances.

The coal cleaning environmental assessment program has as its specific objectives the evaluation of pollution and pollution control problems which are unique to coal preparation, storage, and transportation. The coal preparation industry is a mature yet changing industry, and in recent years significant achievements have been made in pollution abatement. As an aid in the evaluation of an advanced physical coal cleaning facility being constructed near Homer City, Pennsylvania, an existing computer program was verified and modified to simulate the design and operation of physical coal preparation plants. Specifically, this report provides user documentation (Volume I) and programmer documentation (Volume II) for Coal Preparation Simulation Model Version 4 (CPSM4) as modified by Battelle.

PREFACE

Since July, 1976, Battelle's Columbus Laboratories has been conducting a major study for the U.S. EPA on the environmental assessment of coal cleaning processes. In one portion of this study, existing computer programs capable of modeling coal preparation plants were verified and modified to aid in the evaluation of an advanced coal cleaning facility being constructed at Homer City, Pennsylvania. The only computer program found with the required capabilities was one developed in FORTRAN under the technical leadership of the U.S. Bureau of Mines and the sponsorship of the U.S. EPA. The original version of this program, Coal Preparation Simulation Model Version 4 (CPSM4) is described in Gottfried, Jacobsen, and Vaillant(1)*.

This document describes in detail a Battelle modified program CPSM4. The Battelle version of CPSM4 maintains all of the basic capabilities of the original version; however, these have been restructured and augmented extensively to make the program usable in the evaluation of a particular plant.

The actual presentation is divided into two volumes: the first contains user documentation and the second contains program documentation. The goal of the first volume is to make the program a usable and understandable tool for the nonprogrammer interested in the simulation of coal preparation plants. The second volume is intended for individuals with knowledge of the FORTRAN language who are interested in the detailed implementation of the material presented in Volume I.

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* Reference numbers refer to the Reference List at the end of Volume I. A separate reference list is included at the end of Volume II.

Although pages in each volume are numbered sequentially, tables and figures are numbered by volume, chapter, and part followed by a sequence number as shown below. The numbering of equations begins at (1) within each part.

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¦   ¦  ¦ :
¦   ¦  ¦ sequence number
¦   ¦  ¦
¦   ¦  part
¦   ¦
¦   chapter
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volume
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ABSTRACT

This report documents a steady state modeling system that simulates the performance of coal preparation plants. This modeling system was developed originally under the technical leadership of the U.S. Bureau of Mines and the sponsorship of the U.S. Environmental Protection Agency. The modified form described in this report was developed by Battelle for the U.S. Environmental Protection Agency. The system is written in FORTRAN.

The original purpose of the modifications was to make the program usable in the evaluation of an advanced coal cleaning facility being constructed at Homer City, Pennsylvania. Subsequent changes were made to allow the model to be used for a wider range of performance and cost evaluations. Initial changes to the original program were made to (1) increase the number of process operations which could be similated and (2) simplify operation of the program. Later modifications were made to permit the calculation of plant water flows and the estimation of plant costs.

The report is divided into two volumes; Volume I contains user documentation, and Volume II provides program documentation. The manner in which flows of coal are represented and the mathematical approach of the various unit operations are discussed in detail in Volume I. Also, the approach taken for the evaluation of costs is presented. The preparation of the input and the interpretation of the output are described in terms of an example. In Volume II, the program documentation begins with a discussion of the basic principles of documentation and then presents each routine and common block in the system in terms of these principles.

This report covers work during the period from July 1976 through July 1979.

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The advice, counsel, and comments of the EPA Project Officer, Mr. James D. Kilgroe, and others at the IERL/RTP facility were invaluable in performance of this work.

I USER HANDBOOK

1.0 INTRODUCTION

The computer program described in this document resulted from a modeling effort related to existing software in the area of coal preparation simulation. The original purpose was to review and modify this software to aid in the evaluation of an advanced coal cleaning facility being constructed at Homer City, Pennsylvania. The resulting computer program described here more than satisfies this goal in that it is not restricted to simulating the Homer City coal preparation plant; it is able to simulate coal preparation plants in general. Four computer programs were surveyed:

(1) A coal preparation plant simulation model (CPSM4), described in Gottfried, Jacobsen, and Vaillant(1)

(2) A program to perform complete coal washability and froth flotation calculations and to automatically plot all washability curves, described in Humphreys, Leonard, and Buttermore(2)

(3) Coal cleaning programs designed by PEDCo-Environmental, described in Isaacs(3)

(4) A computer simulation model for coal preparation plant design and control, described in Walter(4).

Each of these programs contained unique features which hopefully will be available at some future date in a single program. However, only the coal preparation plant simulation model was sufficiently flexible to be directly usable in the evaluation of the Homer City Plant. This program was, therefore, selected for modification.

The original purpose for the modeling effort directed by the U.S. Bureau of Mines that resulted in the construction of program CPSM4 was to give the user the ability to simulate "the performance of ... configurations representative of actual preparation plants".(1) The key word in the above purpose is representative. The program was not originally designed to simulate actual plant conditions. Rather its role was to give users the ability to examine a representative picture of some configuration as it might impact on a given type of coal. Such analysis is important and valuable for the various design tasks which might precede the actual construction of a plant or, more importantly, which might precede the very decision to build a plant.

With this purpose in mind, the authors of the program made every effort to derive algorithms and generalized coefficients which would adequately represent the behavior of the various types of equipment listed in Figure I-1-0.1. These algorithms included generalized distributed curves, classification functions, selection for breakage functions, breakage distributions, and others, all of which will be discussed in detail in Chapter I-04. This work was very well formulated and programmed in the original version of the program.(1) It is a major asset to the design effort and all of it has been maintained in the present version of the program, though in slightly different form.

The goal of this research effort was not to simulate a representative configuration; rather it was to simulate a particular plant--the Homer City plant. Actual design curves describing the expected performance of units of equipment in the plant were available. Eventually, actual performance curves also will be available when the plant becomes operational. The goal set for the program was to generate results which agreed as closely as possible with the material balance prepared by the design team for the plant. To achieve this goal, it was necessary to modify the program to deal not just with generalized descriptions of equipment behavior but also with particular descriptions--those used by the designers in preparing the material balance. This basic modification was the purpose of the modeling effort which resulted in the version of CPSM4 described herein.

Unit Operation	Equipment Type
Blending	Stream blender
Splitting	Stream splitter
Screening	Dry upper screen
	Dry lower screen
	Wet upper screen
	Wet lower screen
Single-stage washing	Concentrating table
	Dense medium vessel
	Dense medium cyclone
	Hydrocyclone
	Single-stage Baum jig
	Classifying cyclone
Two-stage washing	Two-stage Baum jig
Froth flotation	Froth flotation cell
Rotary breaking	Rotary breaker
Crushing	Primary multiple roll crusher
	Primary gyratory/jaw crusher
	Primary single roll crusher
	Primary cage mill crusher
	Secondary multiple roll crusher
	Secondary gyratory/jaw crusher
	Secondary single roll crusher
	Secondary cage mill crusher
Dewatering	Centrifuge
	Dryer

FIGURE I-1-0.1. UNIT OPERATIONS SIMULATED

1.1 Conclusions

The major purpose of this effort was to modify program CPSM4 so that it could be used in the evaluation of an actual coal cleaning plant. In this context the term could be used was taken to have two levels of meaning. In one sense, it was assumed that the program could be used for a particular plant only if it could reproduce the performance, or expected performance, of that plant. In this sense the utility of the program is measured in terms of its predictive ability. In the other sense, it was assumed that the program could be used for a particular plant only if the personnel associated with that plant felt that they understood the mathematics of the simulation and knew how to control it. The point here is that no matter what the predictive ability of a program might be, it will not be used if the staff who require its use either cannot control it or do not understand it.

That the program is now able to produce plant performance predictions in agreement with design predictions, given equipment performance data, has been demonstrated in the Homer City application. Actual performance data was not available for comparison. The process modeling approach seems ideally suited to the simulation of coal preparation plants. In this sense, the purpose of the effort has been achieved, at least from the design standpoint.

From the other standpoint, the facts are not yet clear. There are currently plans underway to distribute the program and this document to many users. After that has been done, conclusions on its utility can be drawn.

1.2 Recommendations

There are two general recommendations to be made. In the first place there are currently two versions of the program in use, which do not produce the same results. The different results stem from two services:

(1) An error was found in the code for the rotary breaker unit operation in the original version of CPSM4; this has been corrected in the present version of the program.

(2) For a two-stage Baum jig, the particular C-generalized distribution curves used within the program give slightly different results than the generalized distribution curves used in the original version of CPSM4; this difference arises from a recalibration of the curves done in the present version of the program.

To avoid confusion and misunderstanding, these differences should be removed. Some compromise may be needed to accomplish this. The versions have different objectives and need not be structured in the same way; however, they should produce the same result when presented with the same problem.

The other recommendation is that the program be used as widely as possible in as many different situations as possible. This use will almost certainly lead to the discovery of problems both with the program and with this documentation, which would then have to be corrected. It is only in this way, however, that a truly useful tool can be developed.

2.0 OVERVIEW

Program CPSM4 is a computer program which simulates certain aspects of the performance of a coal preparation plant. Generically, it is a steady-state processing modeling system. The term process refers to the fact that CPSM4 views a coal preparation plant as consisting of a set of components, or units of equipment interconnected via a set of flows of coal which they manipulate. The term steady-state refers to the assumption made within CPSM4 that the characterizations of neither the behavior of the unit operations nor the flows vary as a function of time. The formalization of a coal preparation plant as a process is ideal. The steady-state assumption is clearly a reasonable but simplifying one. No attempt will be made in this presentation to justify this methodological approach to the simulation of a coal preparation plant. It is taken as given.

The program, then, considers a coal preparation plant to be composed of a set of discrete interconnected units which perform operations on the flow of coal. The term unit operation refers to the mathematical operation used to simulate a given equipment type. Figure I-1-0.1 shows the particular types of unit operations presently included along with a list of the actual equipment types simulated using those unit operations.

The use of program CPSM4 requires three types of information: first, a float-sink type specific gravity analysis of the coal to be processed; second, a configuration showing the units of equipment as they are to be applied to the coal; and third, an equipment inventory describing the performance of each equipment type relative to the unit operations. The program will then produce an analysis of the performance of each unit of equipment, a specific gravity analysis of each output flow from each unit, a summary of the unit performances, and a summary of the flow characteristics. The purpose of this volume is to describe user preparation of input for the program, the mathematical operations which the program performs on those inputs, and the meanings of the resultant outputs. This presentation assumes that the reader is familiar with the physical processes and equipment types involved in coal preparation.

To simplify the discussion throughout this volume, two examples are presented here. The first example emphasizes the physical simulation capabilities of CPSM4, while the second emphasizes the cost calculation capabilities.

2.1 A Physical Simulation Example

The physical simulation example was obtained from Gottfried, Jacobsen, and Vaillant(1) and modified to allow the inclusion of water flowstreams, retreatment flowstreams, and centrifuges. Figure I-2-1.1 shows a typical plant configuration which includes all of the general types of equipment which can be treated by the program except a stream splitter. However, since a centrifuge is modeled as a splitter with breakage, splitters are implicitly included in the plant configuration. Table I-2-1.1 shows the specific gravity analysis of the size fractions and composite feed to the plant. As mentioned, these two types of information are required to use the program.

The plant configuration is as follows. The feed, which is 18 inches by 325 mesh in size, enters a rotary breaker whose drum is 20 feet long, 12 feet in diameter, and has an opening size of 6 inches. The refuse from the breaker is sent to a refuse stream. The underflow from the breaker, which is 6 inches by 325 mesh, is sent to a wet double deck screen. The upper deck has a mesh size of 1-1/3 inches, while the lower has a size of 1/2 inch. The overflow from the double deck screen, which is 6 inches by 1/2 inch, goes to a two-stage baum jig with a specific gravity of separation of 1.62. The clean coal output from the baum jig goes to the clean output of the plant. The refuse from the baum jig is blended with the refuse from the rotary breaker. The middling output of the jig is sent to a secondary multiple roll crusher. This crusher has a setting of 0.28 inches. The crushed coal produced here is blended with the underflow of the wet double deck screen. The blended coal then passes through a set single deck screen with a 28 mesh size. The overflow of this screen is cleaned by a concentrating table with a specific gravity of separation of 1.58. The refuse from this table is sent to the refuse stream while the clean is blended into the clean output flow. The underflow from the single deck screen goes to a froth flotation cell whose refuse and clean output are treated appropriately. Finally, both the clean and refuse output flows are passed through centrifuges to dewater the flows.

A detailed washability analysis, shown in Table I-2-3.1, is provided for the feed stream to the plant. Note that no information is provided for the minus 325 mesh material. It is assumed, therefore, in the program and in the configuration that no minus 325 mesh material is present in any of the flows.

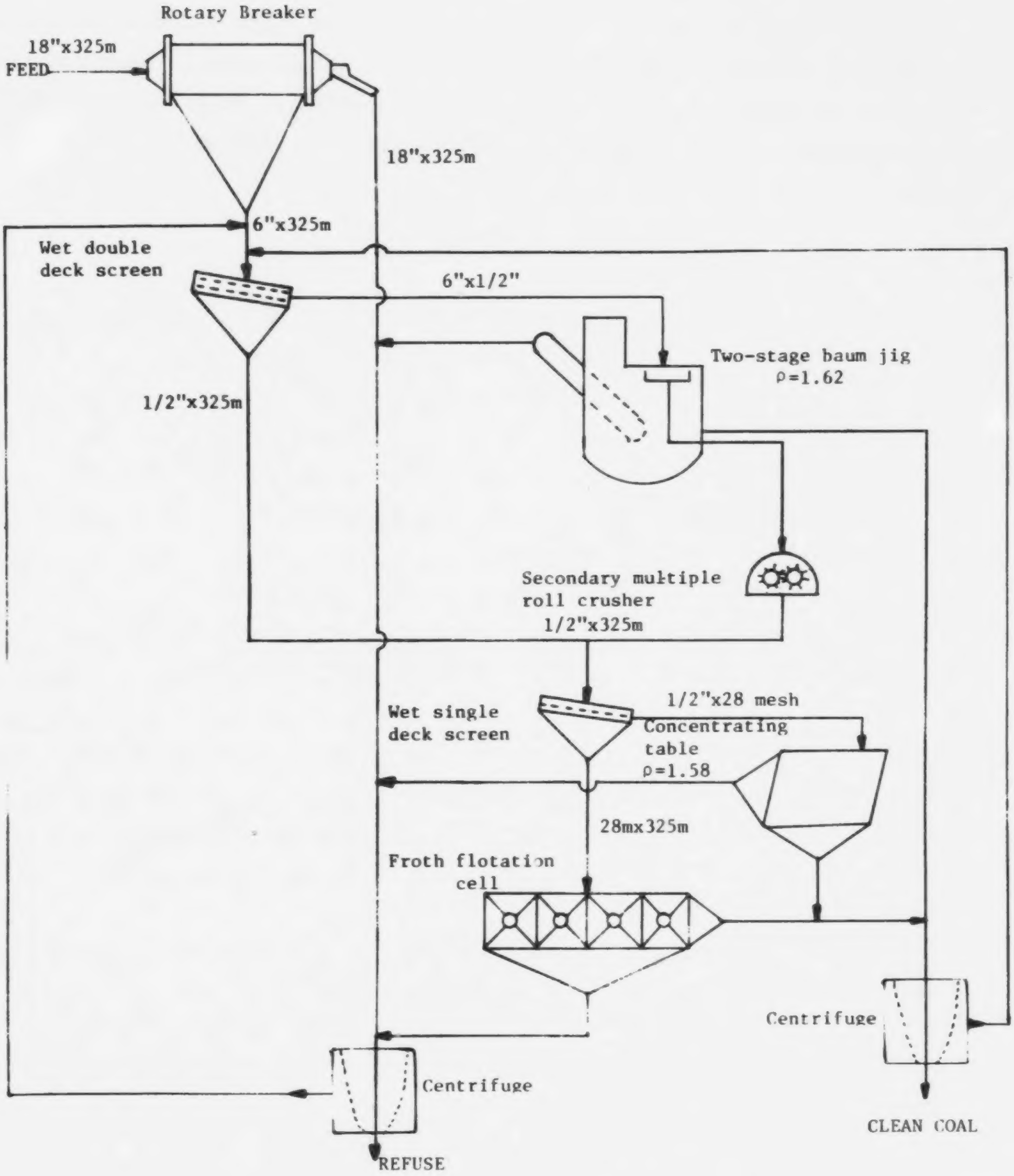
Rotary Breaker
18"x325m
FEED
18"x325m
6"x325m
Wet double deck screen
6"x1/2"
Two-stage baum jig
ρ=1.62
1/2"x325m
Secondary multiple roll crusher
1/2"x325m
Wet single deck screen
1/2"x28 mesh
Concentrating table
ρ=1.58
28mx325m
Froth flotation cell
Centrifuge
Centrifuge
CLEAN COAL
REFUSE

FIGURE I-2-1.1. EXAMPLE OF PLANT CONFIGURATIONS

TABLE I-2-1.1. SPECIFIC GRAVITY ANALYSIS OF THE SIZE FRACTIONS AND COMPOSITE FEED TO THE PREPARATION PLANT

		Direct, percent					Cumulative, percent				
Size fraction and weight	Specific gravity	Weight	Ash	Pyritic sulfur	Total sulfur	Btu/lb	Weight	Ash	Pyritic sulfur	Total sulfur	Btu/lb
18 by 12 Inches 7.1 Percent	Float 1.30	19.7	2.8	.21	.79	15355	19.7	2.8	.21	.79	15355
	1.30-1.35	11.0	4.4	.71	1.57	14907	30.7	3.4	.39	1.07	15194
	1.35-1.40	2.1	7.8	.98	1.59	13909	32.8	3.7	.43	1.10	15112
	1.40-1.50	11.3	15.4	1.10	1.60	12682	44.1	6.7	.60	1.23	14489
	1.50-1.60	2.1	25.0	1.44	1.84	11077	46.2	7.5	.64	1.26	14334
	1.60-1.70	1.9	31.5	2.90	3.50	9723	48.1	8.4	.73	1.35	14152
	1.70-1.80	.8	41.0	5.46	6.13	8269	48.9	9.0	.80	1.42	14056
	Sink-1.80	51.1	84.6	18.43	19.23	1561	100.0	47.6	9.81	10.52	7672
12 by 6 Inches 23.1 Percent	Float 1.30	16.7	2.9	.18	.80	15355	16.7	2.9	.18	.80	15355
	1.30-1.35	14.3	4.7	.62	1.22	14907	31.0	3.7	.38	.99	15148
	1.35-1.40	5.3	9.4	1.05	1.65	13909	36.3	4.6	.48	1.09	14967
	1.40-1.50	5.3	16.7	1.52	2.08	12682	41.6	6.1	.61	1.22	14676
	1.50-1.60	4.1	26.7	1.97	2.47	11077	45.7	8.0	.73	1.33	14353
	1.60-1.70	2.1	35.1	3.23	3.78	9723	47.8	9.1	.84	1.44	14150
	1.70-1.80	1.2	45.7	6.07	6.56	8269	49.0	10.0	.97	1.56	14006
	Sink-1.80	51.0	82.9	17.00	18.14	1563	100.0	47.2	9.14	10.01	7666
6 by 2 Inches 32.2 Percent	Float 1.30	21.4	2.8	.13	.80	15355	21.4	2.8	.13	.80	15355
	1.30-1.35	11.8	4.4	.64	1.32	14907	33.2	3.4	.31	.99	15192
	1.35-1.40	2.2	7.8	1.25	1.85	13909	35.4	3.6	.37	1.04	15115
	1.40-1.50	12.1	15.3	1.88	2.49	12682	47.6	6.6	.76	1.41	14494
	1.50-1.60	1.9	24.9	2.68	3.25	11077	49.5	7.3	.83	1.48	14362
	1.60-1.70	1.7	31.5	4.01	4.66	9723	51.2	8.1	.94	1.59	14208
	1.70-1.80	.7	41.0	5.55	6.30	8269	51.9	8.6	1.00	1.65	14127
	Sink-1.80	48.1	84.6	20.13	20.98	1563	100.0	45.1	10.20	10.95	8085
2 by 1/2 Inches 13.1 Percent	Float 1.30	22.0	2.4	.14	.77	15355	22.0	2.4	.14	.77	15355
	1.30-1.35	19.9	4.7	.49	.99	14907	42.0	3.5	.31	.87	15142
	1.35-1.40	6.9	9.6	.95	1.40	13909	48.9	4.4	.40	.95	14968
	1.40-1.50	7.5	16.1	1.41	1.95	12682	56.4	5.9	.53	1.08	14663
	1.50-1.60	4.5	25.9	2.05	2.49	11077	60.9	7.4	.65	1.19	14398
	1.60-1.70	2.2	34.1	3.51	3.97	9723	63.1	8.3	.75	1.28	14235
	1.70-1.80	1.6	42.3	5.56	6.04	8269	64.7	9.2	.86	1.40	14087
	Sink-1.80	35.3	82.6	17.54	20.02	1563	100.0	35.1	6.75	7.97	9670
1/2 Inch by 8 Mesh 13.0 Percent	Float 1.30	33.5	2.4	.08	.64	15355	33.5	2.4	.08	.64	15355
	1.30-1.35	23.1	4.8	.11	.69	14907	56.6	3.4	.09	.66	15172
	1.35-1.40	7.5	9.7	.45	.92	13909	64.1	4.1	.13	.69	15024
	1.40-1.50	6.9	15.7	.65	1.17	12682	71.0	5.2	.18	.74	14796
	1.50-1.60	3.2	25.7	1.48	1.86	11077	74.2	6.1	.24	.79	14635
	1.60-1.70	1.8	33.8	2.79	3.00	9723	76.0	6.8	.30	.84	14518
	1.70-1.80	1.5	41.4	3.87	4.04	8269	77.5	7.5	.37	.90	14397
	Sink-1.80	22.5	84.2	21.09	21.89	1563	100.0	24.7	5.03	5.62	11514
8 by 28 Mesh 5.6 Percent	Float 1.30	48.0	1.8	.20	.68	15355	48.0	1.8	.20	.68	15355
	1.30-1.35	19.5	4.3	.48	.98	14907	67.5	2.5	.28	.77	15226
	1.35-1.40	5.8	8.8	1.00	1.50	13909	73.3	3.0	.34	.82	15121
	1.40-1.50	4.9	15.4	1.50	2.02	12682	78.2	3.8	.41	.90	14968
	1.50-1.60	2.3	24.4	2.20	2.67	11077	80.5	4.4	.46	.95	14856
	1.60-1.70	1.4	33.3	3.45	4.06	9723	81.9	4.9	.51	1.00	14768
	1.70-1.80	1.1	41.7	6.28	6.70	8269	83.0	5.4	.59	1.08	14682
	Sink-1.80	17.0	82.8	21.02	21.72	1563	100.0	18.5	4.06	4.58	12456
28 by 100 Mesh 3.2 Percent	Float 1.30	59.0	1.8	.16	.73	15355	59.0	1.8	.16	.73	15355
	1.30-1.35	12.5	6.4	.73	1.24	14907	71.5	2.6	.26	.82	15277
	1.35-1.40	8.5	8.3	1.02	1.49	13909	80.0	3.2	.34	.89	15131
	1.40-1.50	4.2	15.5	2.05	2.63	12682	84.2	3.8	.43	.98	15009
	1.50-1.60	2.0	22.8	3.27	3.73	11077	86.2	4.3	.49	1.04	14918
	1.60-1.70	1.0	28.4	4.51	5.17	9723	87.2	4.5	.54	1.09	14858
	1.70-1.80	.6	34.3	6.44	7.22	8269	87.8	4.7	.58	1.13	14813
	Sink-1.80	12.2	67.7	20.43	21.41	1563	100.0	12.4	3.00	3.60	13197
100 by 325 Mesh 2.6 Percent	Float 1.30	36.4	1.2	.10	.64	15355	36.4	1.2	.10	.64	15355
	1.30-1.35	24.0	2.7	.28	.84	14907	60.3	1.8	.17	.72	15177
	1.35-1.40	15.6	4.2	.41	1.01	13909	75.9	2.3	.22	.78	14917
	1.40-1.50	5.6	11.0	1.14	1.66	12682	81.5	2.9	.28	.84	14763
	1.50-1.60	2.3	17.6	2.38	2.98	11077	83.8	3.3	.34	.90	14662
	1.60-1.70	1.0	24.1	4.09	4.32	9723	84.8	3.5	.39	.94	14604
	1.70-1.80	.5	32.2	7.44	8.06	8269	85.3	3.7	.43	.98	14567
	Sink-1.80	14.7	67.3	26.50	26.50	1563	100.0	13.0	4.12	4.73	12657
Composite 100.0 Percent	Float 1.30	25.0	2.5	.14	.74	15355	25.0	2.5	.14	.74	15355
	1.30-1.35	15.7	4.6	.49	1.09	14907	40.6	3.3	.28	.88	15182
	1.35-1.40	5.0	8.7	.88	1.42	13909	45.6	3.9	.34	.94	15043
	1.40-1.50	8.4	15.6	1.54	2.11	12682	54.0	5.7	.53	1.12	14676
	1.50-1.60	3.0	25.6	2.09	2.56	11077	57.0	6.7	.61	1.19	14488
	1.60-1.70	1.8	33.1	3.47	4.00	9723	58.8	7.5	.70	1.28	14340
	1.70-1.80	1.1	42.4	5.46	5.95	8269	59.8	8.2	.78	1.36	14232
	Sink-1.80	40.2	83.5	18.91	20.02	1563	100.0	38.4	8.06	8.86	9145

The actual results of running the configuration against the feed stream are given in Appendix A. The tables in this appendix will be referred to often in the following discussion. They will be referenced as The User Handbook Example.

2.2 Cost Component Example

The source of the cost component example is Holt$^{(5)}$. It is a simple jig process as shown in Figure I-2-2.1. Table I-2-2.1 shows the specific gravity analysis of the feed to the plant.

The plant configuration is as follows.

From the raw coal storage area, the 8 inch by 0 material is conveyed via a 42 inch wide belt to a 6 by 16 foot single deck vibrating screen. As a result of the force of being dropped onto this screen and the vibrating action, the larger pieces of coal are fractured to 6 inches or less. The small amount of material which does not reduce to 6 inches or less passes over the screen and reports to the refuse belt. The 600 tph of 6 inch by 0 raw coal is fed to an eight-cell three-compartment baum type jig. Of the material entering the jig, 372 tph "floats" out and 234 tph sinks as refuse. This refuse goes to a 5 by 10 foot double deck vibrating screen with 1/2 mm openings in the bottom deck where it is partially dewatered before reporting to the refuse belt.

The 372 tph of "float" from the jig goes to two 6 by 16 foot vibrating double deck screens having 3/4-inch and 1/4-inch openings in the top and bottom decks, respectively. Approximately 90 tph of 6 by 3/4-inch coal passes over the top deck and goes to a crusher where it is reduced to 2 inch by 0 before dropping onto the clean coal belt. Passing over the lower deck is 140 tph of 3/4 by 1/4-inch material which goes directly to the clean coal belt. The 1/4-inch by 0 material passing through both decks reports to a sump from which it is pumped to four 20-inch diameter Nihard classifying cyclones at the rate of 142 tph. The 112 tph of 1/4-inch by 48 mesh underflow from these cyclones goes to two 6 by 16 foot desliming screens. All measurable material passes over these screens and is fed to two centrifugal dryers which recover essentially all of the feed. From the dryers, the 1/4-inch by 48 mesh material goes to the clean coal belt.

The 30 tph of 48 mesh by 0 overflow from the 20-inch classifying cyclones reports to a sump from which it is pumped to five 14-inch diameter rubber-lined hydrocyclones. Of this total cyclone feed, 12 tph of 48 by 120 mesh material reports as underflow and goes to a 3 by 12 foot single deck desliming screen. Essentially all of this material passes over this screen

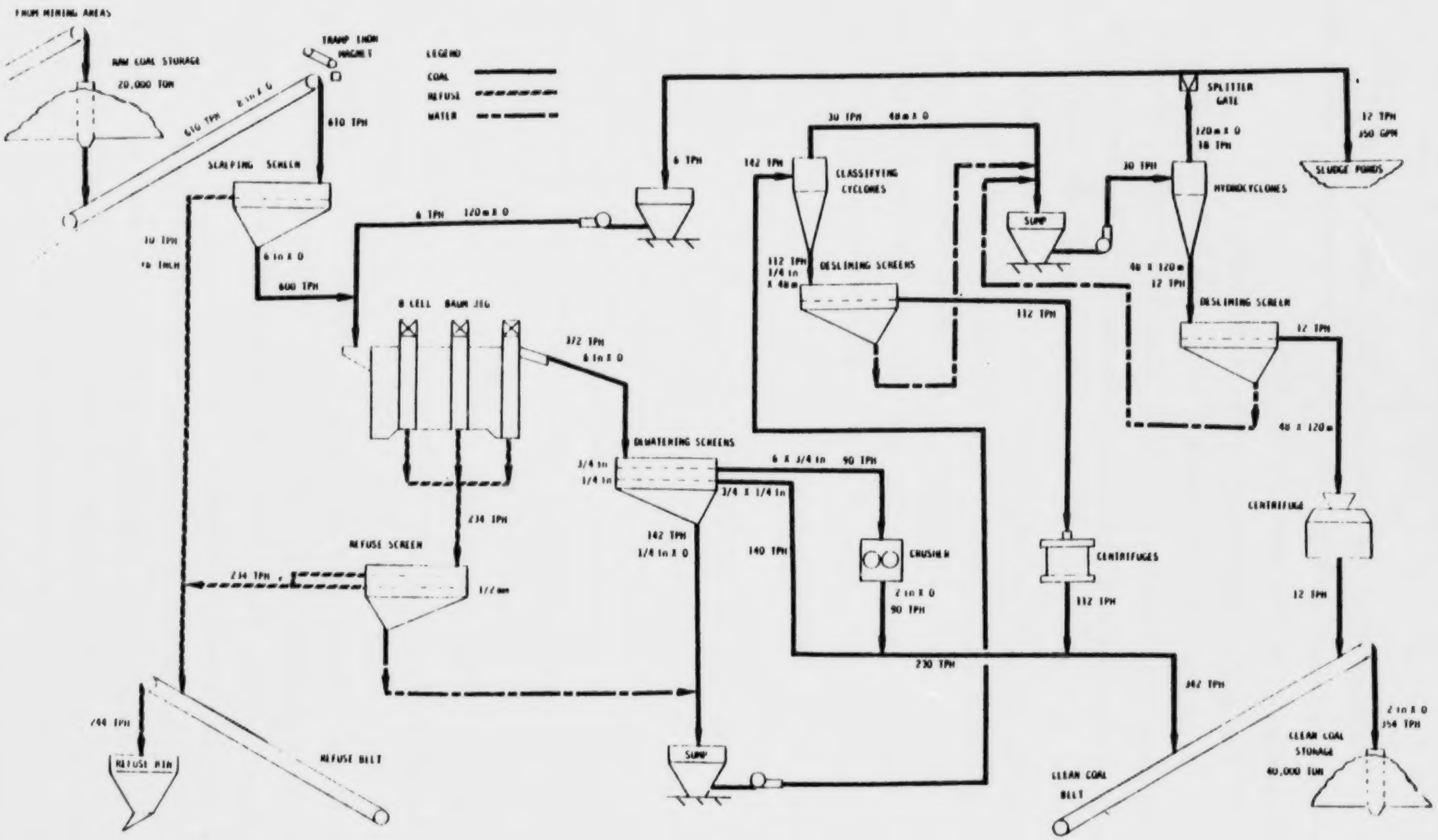
FROM MINING AREAS
RAW COAL STORAGE
20,000 TON
610 TPH 8 in X 0
TRAMP IRON MAGNET
610 TPH
SCALPING SCREEN
10 TPH
+6 INCH
6 in X 0
600 TPH
6 TPH 120 m X 0
6 TPH
LEGEND
COAL
REFUSE
WATER
8 CELL BAUM JIG
372 TPH
6 in X 0
DEWATERING SCREENS
3/4 in
1/4 in
234 TPH
REFUSE SCREEN
234 TPH
1/2 mm
244 TPH
REFUSE BIN
REFUSE BELT
142 TPH
1/4 in X 0
SUMP
6 X 3/4 in 90 TPH
3/4 X 1/4 in
140 TPH
CRUSHER
2 in X 0
90 TPH
230 TPH
142 TPH
CLASSIFYING CYCLONES
30 TPH 48 m X 0
112 TPH
1/4 in
X 48 m
DESLIMING SCREENS
112 TPH
CENTRIFUGES
112 TPH
SUMP
30 TPH
SPLITTER GATE
120 m X 0
18 TPH
HYDROCYCLONES
48 X 120 m
12 TPH
DESLIMING SCREEN
12 TPH
48 X 120 m
CENTRIFUGE
12 TPH
12 TPH
350 GPM
SLUDGE PONDS
342 TPH
CLEAN COAL BELT
2 in X 0
354 TPH
CLEAN COAL STORAGE
40,000 TON

FIGURE I-2-2.1. COST COMPONENT EXAMPLE - JIG PROCESS - SIMPLE PREPARATION PLANT FLOW SHEET

TABLE I-2-2.1. COST COMPONENT EXAMPLE - JIG PROCESS - SIMPLE WASHABILITY DATA OF ASSUMED PLANT FEED

Specific Gravity of Separation	Weight, %	Ash, %	Sulfur, %	Btu/lb	Cumulative Float			
					Weight,%	Ash, %	Sulfur %	Btu/lb
			6 x 3/4 inch--29.75 percent of feed					
Float 1.40	46.42	4.75	0.78	14,003	46.42	4.75	0.78	14,003
1.40-1.45	2.67	13.33	0.76	12,352	49.09	5.23	0.78	13,913
1.45-1.50	1.22	23.63	0.93	10,990	50.31	5.66	0.78	13,842
1.50-1.55	1.06	29.50	0.51	9,880	51.37	6.15	0.78	13,760
1.55-1.60	1.55	55.96	0.42	5,263	52.92	7.61	0.77	13,512
SINK-1.60	47.08	78.89	0.41	2,060	100.0	41.17	0.60	8,120
			3/4 x 0 inch--70.25 percent of feed					
FLOAT-1.40	47.23	4.69	0.78	13,810	47.23	4.69	0.78	13,810
1.40-1.45	4.49	14.67	0.80	11,737	51.72	5.55	0.78	13,630
1.45-1.50	3.0	16.61	0.94	10,219	54.72	6.16	0.79	13,443
1.50-1.55	2.04	21.69	0.87	9,712	56.76	6.72	0.79	13,309
1.55-1.60	1.99	35.99	0.76	7,707	58.75	7.71	0.80	13,119
SINK-1.60	41.25	74.68	0.47	2,388	100.0	35.34	0.67	8,693

and goes to a centrifugal dryer before going to the clean coal belt. There is 18 tph of 120 mesh by 0 overflow from the hydrocyclones which is split between the jig feed sump and the sludge ponds. Of the 18 tph, 6 tph reports to the sump from which it is pumped back to the jig and the balance (12 tph) is sluiced to the sludge ponds along with approximately 350 gallons per minute of water.

A total of 354 tph of 2-inch by 0 material having a heat content of 13,236 Btu/lb drops onto the 36-inch wide clean coal belt and is conveyed to a 40,000 ton open storage area awaiting unit-train load-out.

Holt(5) discusses the capital equipment costs and the operating and maintenance costs of this example. Tables I-2-2.2 and I-2-2.3 give details of the costs as estimated in Holt(5). These figures are based on operating the plant 2600 hours per year with a 10-year amortization of the capital costs.

The cost component example given in Appendix B includes a simulation of this plant configuration. No equipment performance data were given in Holt(5) for this plant so these data had to be assumed in this simulation. Despite this, the results of the simulation agree well with the design data given in Holt(5). As may be seen from pages 6 and 7 of Appendix B (pp. 229-230), the simulation predicts a clean output flow of 364 tph (flowstream 26), a refuse flow of 223 tph (flowstreams 30 and 31) with 13 tph reporting to sludge ponds (flowstream 27). The corresponding figures from Holt(5) are 354 tph, 234 tph, and 12 tph as seen in Figure I-2-2.1. While the flow rates of some flowstreams internal to the plant agree less well with Holt(5), the overall agreement of the simulation with the design is good.

TABLE I-2-2.2. COST COMPONENT EXAMPLE - JIG PROCESS - SIMPLE PREPARATION PLANT CAPITAL REQUIREMENTS(5)

RAW COAL STORAGE AND HANDLING:		
Raw Coal Storage Area 20,000 Ton Capacity with Stacking Tube, Reclaiming Feeders, and Tunnel	$300,000	
Raw Coal Belt to Plant 42-inch Wide - 200 Feet at $520/foot	104,000	
Tramp Iron Magnet Explosion Proof - Self Cleaning Type	20,000	
Total Raw Coal Storage & Handling Cost		$424,000
PREPARATION PLANT:		
Equipment Cost 6 x 16 foot Single Deck Vibrating Scalping Screen - 1 at $17,500	$ 17,500	
Eight Cell Baum Type Jig - 1 at $176,000	176,000	
6 x 16 foot Double Deck Vibrating Dewatering Screens - 2 at $23,000 each	46,000	
5 x 10 foot Double Deck Vibrating Refuse Dewatering Screen - 1 at $18,000	18,000	
Crusher - 1 at $12,100	12,100	
Classifying Cyclones - 20 inch diameter - Nihard - 4 at $2,400 each	9,600	
Hydrocylones - 12-inch diameter - Rubber Lined - 5 at $1,300 each	6,500	
3 x 10 foot Single Deck Desliming Screen - 1 at $12,000	12,000	
Centrifugal Dryer - 1 at $23,200	23,200	
Centrifugal Dryers - 2 at $28,200 each	56,400	
6 x 16 foot Single Deck Desliming Screens - 2 at $16,000 each	32,000	
Sumps - 3 at $10,000 each	30,000	
Pumps	75,000	
Total Preparation Plant Equipment		$514,300
Total Cost of Preparation Plant - Including Site Preparation, Construction of Building, Electrical Service, Piping, etc. $514,300 x 3.0		$1,542,900

(Continued)

TABLE I-2-2.2. (Continued)

OTHER FACILITIES AND EQUIPMENT:		
Clean Coal Belt - 36 inches Wide 300 feet at $480 per foot	$144,000	
Clean Coal Storage Area - 40,000 ton Capacity with Stacking Tube, Reclaiming Feeders, etc.	350,000	
Refuse Belt - 36 inches Wide 250 feet at $480 per foot	120,000	
Refuse Bin	50,000	
Raw Coal and Refuse Handling Equipment - 2 Dozers at $150,000 each	300,000	
Unit-Train Loading Facility	500,000	
Total Other Facilities & Equipment		$1,464,000
SUMMARY OF CAPITAL COST:		
Raw Coal Storage and Handling	$ 424,000	
Preparation Plant	1,542,900	
Other Facilities and Equipment	1,464,000	
Contingency (Interest during Construction, etc.)	515,000	
Total Capital Requirement		$3,945,900

Based upon the 600 ton per hour input to this plant, the Capital Requirement translates to $6,600 per ton/hour of input

TABLE I-2-2.3. COST COMPONENT EXAMPLE - JIG PROCESS - SIMPLE OPERATING AND MAINTENANCE COSTS(5)

Cost Category	Cost per Ton (Raw Coal)	Cost per Ton (Clean Coal)
Labor		
Supervisory (Non-Union)	$0.044	$0.075
Operating and Maintenance (Union)	0.303	0.514
Overhead		
Fringe Benefits - 25% Non-Union	0.011	0.019
- 21% Union	0.064	0.108
Other - Includes Welfare Fund, Payroll Taxes, Property Taxes, Insurance, etc.	0.059	0.100
Supplies		
Operating	0.155	0.262
Maintenance	0.148	0.251
Major Maintenance - Scheduled Repairs and Plant Improvements	0.134	0.228
Electricity	0.073	0.123
Subcontract Services to Dip Sludge Ponds, Haul Refuse and Miscellaneous Expenses	0.599	1.016
O&M Cost - Not Including Capital Amortization	$1.59	$2.70
Capital Amortization - 10 yrs.-30% Utilization	0.38	0.65
Total Operating & Maintenance Cost	$1.97	$3.35
Cost Per Million Btu (12,111 Btu/lb)		$0.138

3.0 REPRESENTATION OF FLOWS

The fundamental notion within program CPSM4 is that of a flow of coal. It is these flows which the unit operations manipulate. Each unit operation accepts certain flows as input and produces certain flows as output. All of the mathematical operations performed by the routines simulating the various units manipulate flow representations. Furthermore, from the standpoint of the user of the program, the performance of any given unit is measured in terms of the changes induced in the flows being manipulated. This fact corresponds to the real world situation in that an engineer can evaluate the performance of a given unit or a circuit or an entire plant only by studying the characteristics of the output flows of coal as measured in terms of the characteristics of the input flows.

Describing the mathematical algorithms used to simulate a particular type of unit operation in a coal preparation plant involves describing how the relevant portions of the program manipulate flow representations. This chapter, then, describes how flows of coal are represented in program CPSM4. Associated with each flow are two types of information:

(1) $F_{t,s,g}$ - the amount of material of characteristic t in the s-th size fraction and g-th specific gravity fraction.

(2) W - the amount of water in the flow.

In addition, there is a third type of information which, while not associated with the flows internally in the program, is helpful in determining the effect of a given unit operation on a flow. This is the characteristic value, $C_{t,s,g}$, which is the percentage by weight of material of characteristic t that is in size fraction s and specific gravity fraction g, except that for the Btu characteristic, $C_{t,s,g}$ is the Btu per pound.

These are measures of the amount of material within the flow. They may be thought of as weight measures or as rate of flow measures. For the characteristics commonly included in CPSM4, the flow description $F_{t,s,g}$ gives, for size fraction s and specific gravity fraction g, the following information:

(1) Total weight of dry material in the flow per time period.

(2) Weight of ash in the flow per time period.

(3) Weight of total sulfur in the flow per time period.

(4) Weight of pyritic sulfur in the flow per time period.

(5) Total Btu in the flow per time period.

For the ash and sulfur characteristics the type of weight unit used is unimportant insofar as the mathematics of the program is concerned, so long as all the flows are thought of as being measured in the same units. The total weight of material in the flow is assumed in the program to be in tons, or tons per hour; the amount of water in the flow is assumed to be in the same units but for output purposes is converted to gallons per minute.

3.1 The Uniformity Assumption

An important assumption made about the interpretation of the flow characteristic values is that of uniformity. This part discusses that assumption. It is an explicit assumption within the program that all characteristics which pertain to a given size and/or specific gravity fraction are uniformly distributed over that fraction. In other words, it is assumed that all of the material in that fraction has the same value for the characteristic being measured.

To make the impact of this assumption a bit clearer, consider Figure I-3-1.1, which shows the direct percent ash plotted versus specific gravity for the composite feed shown in Table I-2-3.1. The area bounded by the rectangles shows the relationship under the uniform distribution hypothesis; while the other line was formed by connecting the midpoints of the specific gravity fractions.

Assume now that an estimate were desired for the direct percent ash for the material at some specific gravity - say 1.60. Under the uniform distribution hypothesis, the answer would be 33 percent while under the hypothesis connecting the midpoints it would be 30 percent. In the particular application chosen, the 30 percent answer seems better. Equivalent results could be obtained when looking at averages over specific gravity intervals. Thus, the average direct percent ash for the interval 1.60 to 1.70 would simply be 33 percent while under the other it would be 32 percent.

In each case, the second estimate, which does not assume a uniform distribution, seemed better. The reason is obvious. As specific gravity increases, the direct percent of ash also increases. The second assumption captures this additional relationship, while the uniformity assumption does not. Why then does the program assume uniformity? There are two reasons. First, the uniformity assumption is computationally much simpler to implement, and second, it is not obvious what different assumption would give better results in general. It is not at all certain that all variables would vary as neatly as does direct percent ash. From the standpoint of maximal generality, the uniformity assumption is both easy to implement and reasonable. From

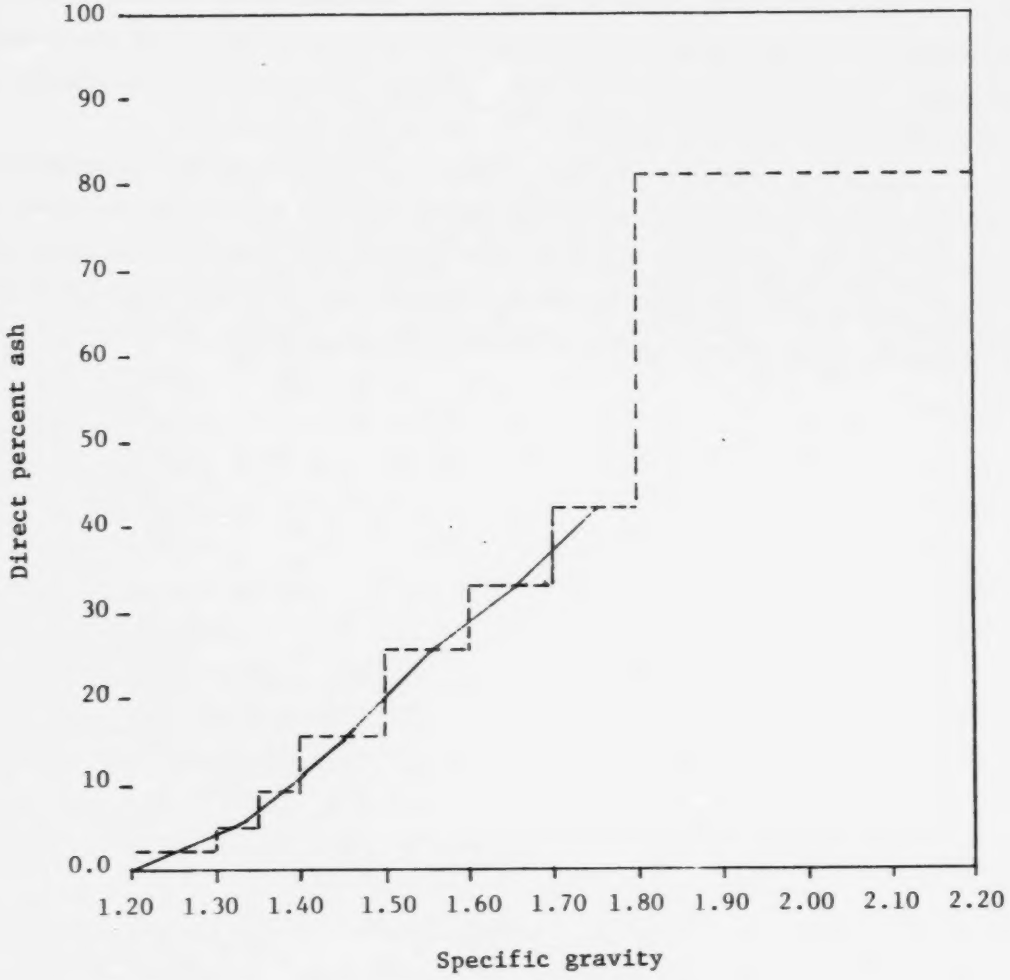

FIGURE I-3-1.1. DIRECT PERCENT ASH

the standpoint of this discussion, it is important only that the reader understand that this assumption is being made and that he be a little wary as a result. The only point where difficulties might arise is in the screening algorithm. (See the discussion of the uniformity assumption in screening given in Part I-04-03.)

The above comments are not intended to imply that the application of the uniformity assumption can lead to problems in maintaining the material balance. This is not true. The material balance will always be maintained by CPSM4. This topic will be discussed in detail in Part 3 of Chapter 4 of this section, which discusses the screening unit operation.

3.2 Classifying Unit Operations

An important way in which the algorithms for the unit operations of Figure I-1-0.1 can be distinguished is by whether or not the result produced by the algorithm has any impact on the values for the $C_{t,s,g}$. A given unit will be said to have characteristic invariance, if, and only if, all output flows for the unit have the same set of $C_{t,s,g}$ as the input flows. Within program CPSM4 the following unit operations exhibit characteristic invariance:

- Single-stage washing
- Two-stage washing
- Froth flotation
- Screening
- Splitting.

The following do not exhibit characteristic invariance:

- Rotary breaking
- Crushing.

Blending is a special case in that it has characteristic invariance if and only if all input flows have identical values for the $C_{t,s,g}$. The above points will be developed more fully in the parts dealing with the particular unit operations (see Chapter I-04).

Closely related to the notion of characteristic invariance for classifying algorithms for unit operations is the notion of characteristic independence. The algorithm for a given unit operation will be said to exhibit characteristic independence if and only if the algorithm does not take the values of the $C_{t,s,g}$ for the input flows into account in determining the values of the $F_{t,s,g}$ for the output flows. Within CPSM4 only the algorithm for the froth flotation cell does not have characteristic independence. On the other hand, it does have characteristic invariance.

Now that the basic flow representation has been described, the unit operations can be discussed. The discussion will assume the notation and basic concepts developed in this chapter.

3.3 Retreatment Flows

Much of the water in a coal cleaning plant is recycled within the plant. In order to be able to simulate this recycling, it is necessary to be able to model retreatment streams. Such flowstreams have the property that they are input streams to units which occur earlier in the configuration than the unit at which they are computed. Thus, on the first cycle through the configuration, the retreatment flowstreams have unknown properties. For example, in the User Handbook example of Appendix A, flowstream 25 is an output flowstream from unit 15 and an input flowstream to unit 2. When unit 2 in the configuration is simulated initially, the properties of the input flowstream 25 are unknown; they are not computed until unit 15 has been simulated. CPSM4 has been modified so that in the event of retreatment streams being present, the entire configuration will be processed as many times as is necessary to achieve convergence of the composite characteristics of the retreatment flowstreams. It is assumed that only blenders will have input streams that are retreatment streams. This means that the check to determine whether the current unit is a retreatment unit need be done only for blenders. On the first pass through the configuration, the retreatment streams are assumed to be empty (although if they contain water, this will automatically be added by the blender if the percent moisture decision variable is present). On subsequent passes through the configuration, the characteristics used for the retreatment streams are those calculated on the previous iteration.

For a retreatment unit the number of input streams to the unit is fewer on the first pass through the configuration than on subsequent passes since the retreatment streams are ignored at first. So the retreatment unit must be able to handle a variable number of input streams, effectively restricting such units to being blenders. Blenders are able to blend from one to six input streams.

To reduce the number of iterations required for convergence of the retreatment flowstream characteristics, the convergence acceleration procedure used in the original version of CPSM4 was used in the present program. This is the Aitken-Steffenson convergence acceleration procedure in which, after three evaluations x_0, x_1, x_2 of the flow rate of a retreatment stream, a new flow rate x_0^1 is computed from

$$x_0^1 = x_2 - \frac{(x_1 - x_0)^2}{(x_2 - 2x_1 + x_0)} \quad .$$

x_0^1 is then used as the starting point x_0 from which to calculate x_1^1 and from that x_2^1 and hence a new x_0^{11}. Thus, on all odd iterations through the configuration except the first, the flow rate is adjusted by the formula given above so as to accelerate convergence. Since CPSM4 stores all the detailed flow-stream data in additive form, the adjustment of the coal flow rate is made to all elements in the detailed flow description array. This is done by computing the scale factor x_0^1/x_2 and scaling all the flow description elements by this amount. The flow rate of the water in the stream is also adjusted by this convergence acceleration procedure.

4.0 THE UNIT OPERATIONS

Within program CPSM4 flows are manipulated by units within the user specified plant configuration whose mathematical treatment of the flow representations is intended to model the effect on actual flows of coal of actual units of equipment in a coal preparation plant. Each unit that the user specifies is assigned an equipment type. Figure I-1-0.1 showed the types of equipment which have been modeled to date using program CPSM4. Within a given plant configuration, there may be several non-identical units of the same equipment type. Different units of the same equipment type are distinguished via the values of particular decision variables. As an example, a given configuration might have two wet upper screens, one with a mesh size of 1-1/2 inches and one with a mesh size of 8 mesh. Both would be simulated with the same equipment type. One would have a decision variable setting of 1.5 inches; while the other would have a setting of 8 mesh. This concept will be developed fully in the following discussion.

The notion of a unit operation is one level of abstraction above that of an equipment type. Many different equipment types may be mathematically implemented via the same unit operation. Figure I-1-0.1 showed the nine unit operations currently implemented in the program along with the equipment types using them. Any two equipment types using the same unit operation have the same general mathematical approach--i.e., model structure. They differ in terms of the actual values of coefficients within the equations used to actually implement the mathematical structures.

This chapter describes in considerable detail the mathematical treatment given to the flow representations by the nine unit operation types.

4.1 Blending

The mathematics of blending is perfectly straightforward. A blender has one output flow and up to six input flows. If $F_{o,t,s,g}$ represents the flow description of the output flow and $F_{I_i,t,s,g}$ $(i = 1,\ldots,6)$ represent the flow descriptions of the input flows, then

$$F_{o,t,s,g} = \sum_i F_{I_i,t,s,g} \quad . \tag{1}$$

If W_o represents the water content of the output flow and W_{I_i} $(i = 1,\ldots,6)$ represent the water contents of the input flows, then

$$W_o = \sum_i W_{I_i} \quad . \tag{2}$$

These two equations complete the basic description of the mathematics of blending. However, there is an additional feature which may be used to increase the amount of water in the output flow. The user may supply a desired percent moisture level for the output flow. Such user-specified variables are referred to as decision variables. If the desired percent moisture level of the output flow is D1 and if D1 is greater than the percent moisture of the output flow as determined from equation 2, then W_o is modified to increase the percent moisture level to D1. Note as stated on page I-03-00-02 that for t equals 1, F contains the total weight of material.

i.e., if
$$\frac{D1}{100} > \frac{W_o}{W_o + \sum_{s,g} F_{o,1,s,g}} \tag{3}$$

then
$$W_o = \frac{D1 \sum_{s,g} F_{o,1,s,g}}{(100 - D1)} \quad . \tag{4}$$

Note that while a blender can add water to the plant, it can never decrease the amount of water in the output flow so as to "lose" water from the plant. The blender is the only unit operation capable of adding water in this manner. No unit operations "lose" water.

The calculation of the characteristic values of the output flow, $C_{o,t,s,g}$ from $C_{I_i,t,s,g}$ is slightly more complex than the above. Now

$$C_{o,t,s,g} = \frac{F_{o,t,s,g}}{\sum\limits_{s,g} F_{o,1,s,g}} \quad . \qquad (5)$$

so that

$$\begin{aligned}
C_{o,t,s,g} &= \sum_i F_{I_i,t,s,g} \Big/ \sum_i \sum_{s,g} F_{I_i,1,s,g} \\
&= \sum_i \left(\frac{F_{I_i,t,s.g} \sum\limits_{s,g} F_{I_i,1,s,g}}{\sum\limits_{s,g} F_{I_i,1,s,g}} \right) \Big/ \sum_i \sum_{s,g} F_{I_i,1,s,g} \\
&= \frac{\sum\limits_i C_{I_i,t,s,g} \cdot \sum\limits_{s,g} F_{I_i,1,s,g}}{\sum\limits_i \sum\limits_{s,g} F_{I_i,1,s,g}} \qquad (6)
\end{aligned}$$

In terms of the constancy of the characteristic values, note that if

$$K = C_{I_i,t,s,g} \quad , \quad i = 1,\ldots,6$$

then

$$\begin{aligned}
C_{o,t,s,g} &= \sum_i K \cdot \sum_{s,g} F_{I_i,1,s,g} \Big/ \sum_i \sum_{s,g} F_{I_i,1,s,g} \\
&= K \sum_i \sum_{s,g} F_{I_i,1,s,g} \Big/ \sum_i \sum_{s,g} F_{I_i,1,s,g} \qquad (7) \\
&= K
\end{aligned}$$

Thus, if all input flows have the same characteristic values, then the output flow will have that same set of characteristic values. This is characteristic invariance as defined earlier.

As an example of the calculation of the characteristic values of the output flow of a blender, assume that two coal streams are blended, one having 2000 T of coal containing 10% moisture, 2% sulfur and having

12,000 Btu/lb, the second flowstream having 1000 T of coal containing 6% moisture, 1.4% sulfur and having 14,000 Btu/lb. Then

$F_{1,1}$ = 1800 T = weight of dry material in flowstream 1

$F_{2,1}$ = 940 T = weight of dry material in flowstream 2

$F_{1,3}$ = 36 T = weight of sulfur in flowstream 1

$F_{2,3}$ = 13.16 T = weight of sulfur in flowstream 2

$F_{1,5}$ = 432×10^8 Btu = total Btu in flowstream 1

$F_{2,5}$ = 263.2×10^8 Btu = total Btu in flowstream 2

W_1 = 200 T = weight of water in flowstream 1

W_2 = 60 T = weight of water in flowstream 2

$C_{1,3}$ = 2 = % sulfur in flowstream 1

$C_{2,3}$ = 1.4 = % sulfur in flowstream 2

$C_{1,5}$ = 12,000 = Btu/lb for flowstream 1

and $C_{2,5}$ = 14,000 = Btu/lb for flowstream 2.

If flowstream number 3 represents the output of the blender, then

$F_{3,1}$ = 2740 T = weight of dry material in flowstream 3

$F_{3,3}$ = 49.16 T = weight of sulfur in flowstream 3

$F_{3,5}$ = 695.2×10^8 Btu = total Btu in flowstream 3

and W_3 = 260 T = weight of water in flowstream 3.

The characteristic values of flowstream 3 are

$$\begin{aligned} C_{3,3} &= \text{\% sulfur in flowstream 3} \\ &= (C_{1,3} \cdot F_{1,1} + C_{2,3} \cdot F_{2.1})/(F_{1,1} + F_{2,1}) \\ &= (2 \times 1800 + 1.4 \times 940)/(1800 + 940) \\ &= 4916/2740 \\ &= 1.79 \end{aligned}$$

and $C_{3,5}$ = Btu/lb for flowstream 3

$$= (C_{1,5} \cdot F_{1,1} + C_{2,5} \cdot F_{2,1})/(F_{1,1} + F_{2,1})$$

$$= (12{,}000 \times 1800 + 14{,}000 \times 940)/(1800 + 940)$$

$$= 34{,}760{,}000/2740$$

$$= 12{,}686.$$

In addition, the percent moisture of the output flowstream is computed as

$$\frac{W_3}{(F_{3,1} + W_3)} \times 100 = \frac{260}{(2740 + 260)} \times 100 = 8.67\% \quad .$$

4.2 Splitting

The mathematics of splitting are as straightforward as those of blending; however, splitting requires that the user specify a decision variable in addition to an optional percent moisture decision variable. The following discussion describes the mathematics of splitting.

Splitting is viewed as being a simple unit operation which takes one input flow, whose quantities will be represented by the subscript I , and produces two output flows, whose quantities will be represented by the subscripts U (for upper) and L (for lower). The required decision variable, D1, specifies the percentage of material in the input flow that is to be sent to the upper output flow. The output flow descriptions are given by

$$F_{U,t,s,g} = \frac{D1}{100} \cdot F_{I,t,s,g} \tag{1}$$

$$F_{L,t,s,g} = F_{I,t,s,g} - F_{u,t,s,g} \quad . \tag{2}$$

Splitting is set apart from the other unit operations in that the two flows out of the splitter are assumed to have characteristic values identical to those of the input flow and the same distribution of material. The characteristic values of the output flows are

$$\begin{aligned} C_{u,t,s,g} &= \frac{F_{u,t,s,g}}{\sum\limits_{s,g} F_{u,1,s,g}} = \frac{D1}{100} F_{I,t,s,g} \Big/ \sum_{s,g} \frac{D1}{100} F_{I,1,s,g} \\ &= \frac{F_{I,t,s,g}}{\sum\limits_{s,g} F_{I,1,s,g}} = C_{I,t,s,g} \end{aligned} \tag{3}$$

$$\begin{aligned} C_{L,t,s,g} &= \frac{F_{L,t,s,g}}{\sum\limits_{s,g} F_{L,1,s,g}} = \frac{F_{I,t,s,g} - F_{u,t,s,g}}{\sum\limits_{s,g} \left(F_{I,1,s,g} - F_{u,1,s,g}\right)} \\ &= \frac{F_{I,t,s,g}}{\sum\limits_{s,g} F_{I,1,s,g}} \cdot \frac{\sum\limits_{s,g} F_{I,1,s,g}}{\sum\limits_{s,g} \left(F_{I,1,s,g} - F_{u,1,s,g}\right)} - \end{aligned}$$

$$\frac{F_{u,t,s,g}}{\sum_{s,g} F_{u,1,s,g}} \; \frac{\sum_{s,g} F_{u,1,s,g}}{\sum_{s,g} \left(F_{I,1,s,g} - F_{u,1,s,g}\right)}$$

$$= \frac{C_{I,t,s,g} \cdot \sum_{s,g} F_{I,1,s,g} - C_{u,t,s,g} \cdot \sum_{s,g} F_{u,1,s,g}}{\sum_{s,g} \left(F_{I,1,s,g} - F_{u,1,s,g}\right)} \qquad (4)$$

$$= \frac{C_{I,t,s,g} \sum_{s,g} F_{I,1,s,g} - C_{I,t,s,g} \sum_{s,g} F_{u,1,s,g}}{\sum_{s,g} \left(F_{I,1,s,g} - F_{u,1,s,g}\right)}$$

$$= C_{I,t,s,g}$$

Thus, the only difference between the three flows of a splitter is the quantity of material in each flow.

In the absence of a second decision variable, the water content of the input flow is divided between the upper and lower output flows in the same ratio as the flowrates. Thus, in this case the percent moisture content of each output flow is the same and is the same as that of the input flow. However, it is possible to specify the percent moisture content of the upper output flow by specifying a second decision variable, D2. This allows a splitter to be used to remove water from a flowstream so that, for example, a dryer or centrifuge may be simulated. If the decision variable D2 is specified, then

$$W_U = D2 \sum_{s,g} F_{U,1,s,g} \, / \, (100 - D2) \qquad (5)$$

and

$$W_L = W_I - W_U \qquad (6)$$

4.3 Screening

The implementations of the blending and splitting operations within the coal preparation process were simple in that they were purely mathematical - independent of any real empirical data. This simplicity is not possible for the remaining unit operations, as all require empirical data. This empirical data is entered by the user in the form of distributions as well as via decision variables. This discussion introduces this concept and describes the mathematics of screening.

The approach taken to screening assumes that there will be no oversized particles in the underflow, but that there will be undersized particles in the overflow. This assumption is based on the fact that a particle smaller than the screen mesh size does not necessarily pass through the screen. The opposite, however, that a particle larger than the screen mesh size will not pass through the screen is assumed to be true. Associated with any given particle, then, is a probability that that particle will not pass through the screen. This probability, pr, is a function of the particle size and the screen size. Its form is shown in (1) below.

$$pr(ss,ps) = \begin{cases} 1.0 \text{ if } ps \geq ss \\ e^{-A(ss)\cdot(1-ps/ss)} \text{ if } ps < ss \end{cases} \qquad (1)$$

where

ss is the screen mesh size

ps is the particle size

A is a screen type specific distribution over the mesh size.

Vaillant(6), which contains some documentation for the original version of CPSM4, gives a justification for the use of an exponential form for the probability of a particle passing through a screen but does not attempt to justify the use of an exponential form for the probability of a particle not passing through a screen. This equation (1), while reasonable, must be said to be of unclear origin.

The empirically derived adjustment factors, A, have been estimated by Vaillant(6) for four types of screens. Each distribution is a function of mesh size. Figure I-4-3.1 shows these distributions in graphical form. Table I-4-3.1 shows the actual values as they are to be entered into program CPSM4.

To simulate a screen, the user must enter two types of information. First, he must enter the distribution from which the program is to obtain the adjustment factor. This distribution might be used in more than one actual unit in the plant configuration. It would be used for all screens of the same general type. Second, the user must enter a decision variable, D1, representing the mesh size for each particular screen in his plant configuration.

TABLE I-4-3.1. ADJUSTMENT FACTORS FOR SCREENING

Mesh size, inches	Dry upper screen	Dry lower screen	Wet upper screen	Wet lower screen
18.0	60.0	60.0	60.0	60.0
6.0	20.0	20.0	20.0	20.0
1.5	8.0	8.0	9.0	9.0
.375	8.0	6.0	8.6	6.6
.25	5.0	4.0	5.5	4.5
.093	3.0	2.0	3.5	2.3
.0232	0.7	0.7	0.8	0.8
.0164	0.6	0.6	0.7	0.7
.0116	0.5	0.6	0.55	0.55

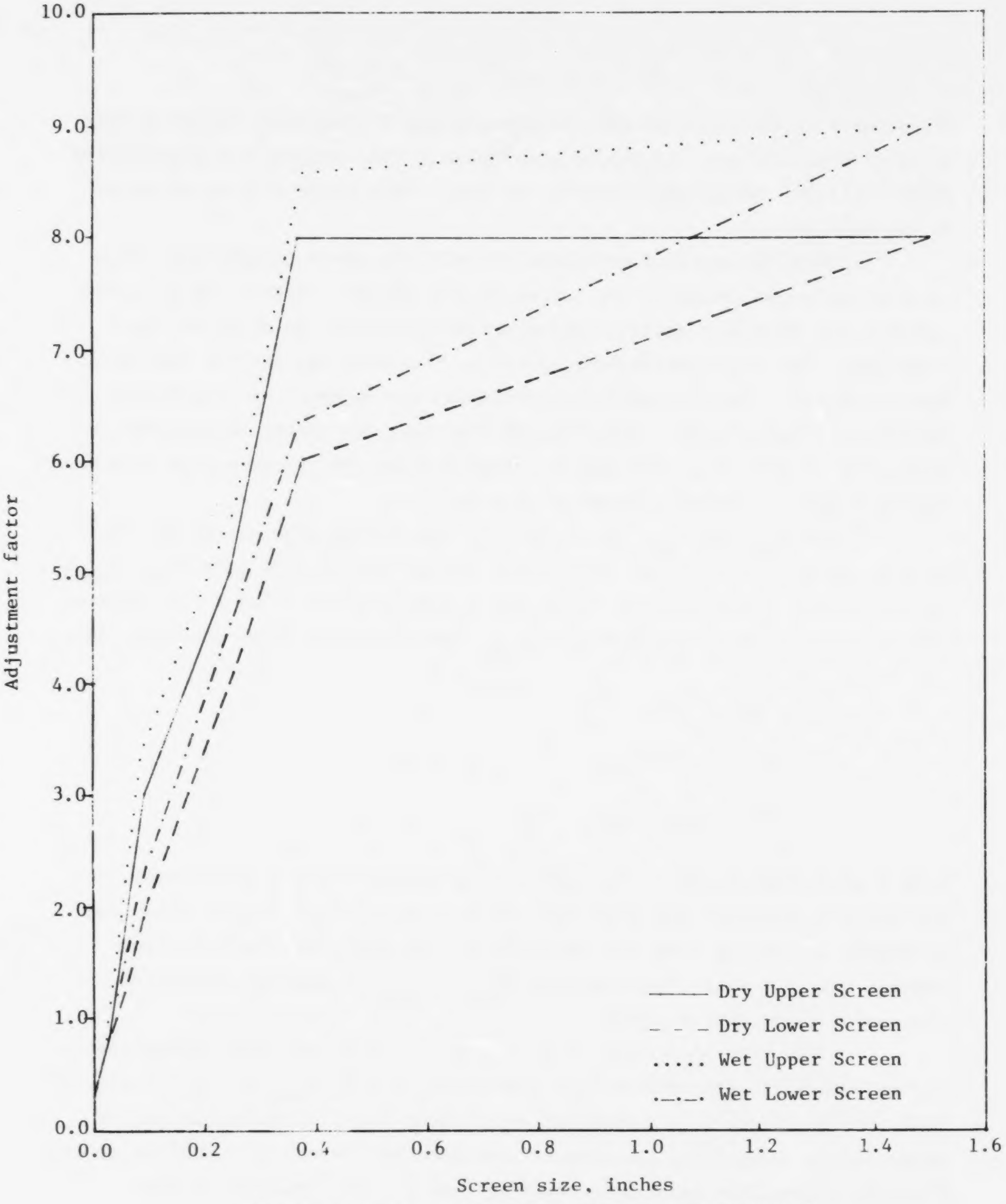

FIGURE I-4-3.1. ADJUSTMENT FACTORS FOR SCREENING

The details of the entry of this information are discussed at length in later parts of this section. It should also be noted that screens can be simulated using explicit classification curves as well. This topic will be discussed in the next chapter.

There is one problem associated with the above formulation. This is that the actual sizes of the particles are unknown. Rather, as discussed earlier, the flow is classified and described generally in terms of size fractions. The size distribution of the coal is defined, not the individual particle sizes. The problem then becomes not to estimate the probability that a given particle will pass through a screen, but rather to estimate the proportion of particles that will not pass through the screen within each size fraction based on the size range of that fraction.

Let S_{min} and S_{max} be the minimum and maximum size values for the material within a given size fraction s. By assumption, the pair $[S_{min}, S_{max})$ forms a closed open interval. Thus, any particle within s has a size greater than or equal to S_{min} and less than S_{max}. Now there are three possible cases.

(1) $S_{max} > S_{min} > ss$

(2) $S_{max} \geq ss \geq S_{min}$

(3) $ss > S_{max} > S_{min}$

Case 1 is straightforward. All material is larger than the screen size, and the ratio of material that will not pass through is 1.0. In Case 3 all the particles are smaller than the screen size. In this case, the algorithm assumes that all particles have size $(S_{max} + S_{min})/2$ (see the discussion of uniformity assumption earlier).

Thus, the proportion of particles that will not pass through the screen equals the probability that a particle of size $(S_{max} + S_{min})/2$ will not pass through. Case 2 is a combination of cases 1 and 3. Using the uniform distribution assumption, the program computes the fraction of particles greater than the screen size and treats these as Case 1. The remainder of the particles are smaller than the screen size and are treated as Case 3. The resultant probability is the weighted average of the two calculations.

The basic approach, then, is to compute a set of values d_s (s being a size fraction), which defines the proportion of the material or flow in each size fraction that will not pass through the screen. It is important to note that the calculation of d_s is strictly a function of the screen size and type and the definition of the size fractions. It is independent of any flow specific information.

Once d_s has been calculated, the generation of the new flow representations is as follows. Let the subscript I represent the input flow values and the subscripts U and L represent the upper (overflow) output flow and lower (underflow) output flow, respectively. The remaining notation is as before.

$$\begin{gathered}
F_{U,t,s,g} = d_s \, F_{I,t,s,g} \\
F_{L,t,s,g} = F_{I,t,s,g} \, (1 - d_s) \\
C_{U,t,s,g} = C_{I,t,s,g} \\
C_{L,t,s,g} = C_{I,t,s,g} \\
W_U = \frac{W_I \sum_{s,g} F_{U,1,s,g}}{\sum_{s,g} F_{I,1,s,g}} \\
W_L = W_I - W_U
\end{gathered} \tag{2}$$

However, the user may enter a second decision variable, D2, representing the desired percent moisture of the upper (overflow) output flow. In that case,

$$\begin{gathered}
W_U = \frac{D2 \sum_{s,g} F_{U,1,s,g}}{(100 - D2)} \\
W_L = W_I - W_U
\end{gathered} \tag{3}$$

Notice that the screening process is nonselective both in terms of specific gravity and the characteristic values. In particular, the characteristic values of the two output flows are identical to each other and are identical to the characteristic values of the input flow.

There is one difficulty in the preceding discussion which the user should be aware of. The assumption of uniform distribution and the assumption that no particle larger than the screen size will pass through it are incompatible. Assume, for example, that the program is simulating the passage of material classified in the size fraction 1/8-inch by 10 mesh (0.065 inch) passing through an 8 mesh (0.093 inch) screen. Now by the assumption that no material larger than the screen size will pass through, most of the material will not be in the underflow stream and that material which is in the underflow screen will all be less than 8 mesh - i.e., it will be in the 8 to 10 mesh size fraction. However, the program assumes the same size classification for all flows and assumes that these are all uniformly classified in those size fractions; therefore, all subsequent processing of the underflow from the 8 mesh screen will assume that the material in the size category is 1/8 inch by 10 mesh and not 8 mesh by 10 mesh. In cases where little detailed sizing data are available, this incompatibility could cause strong biases in the results.

Upon first seeing the above and possibly, upon considering the uniformity assumption in general, the reader might be led to believe that in cases where a screen mesh size does not fall directly on a size fraction boundary the program might not maintain the material balance of the flows. Thus, he might interpret the phrase "strong biases in the results" as used in the preceding paragraph as referring to biases in the material balance. As was stated earlier in this section, this is not the case. The program always maintains the material balance, as it must if the results are to be meaningful. The remainder of this part will discuss this issue with regard to the implementation of the double deck screen in the user handbook example. The detailed mathematics of this issue are quite complex and will not be dealt with in this section. Part 2 of Chapter 4 in Volume II discusses the mathematical problems.

The uniformity assumption comes into play not just when the characteristics of size fractions are needed but also to determine what particular mathematical equation should apply to what size fraction. In the case of the screen, the calculation of the value of d_s depends upon the size fraction bounds. This was specified earlier. The biases referred to earlier relate to the calculation of these values. To bring this point out clearly, a particular example will be presented.

Examining the list of units on page 1 of the user handbook example, notice that no double deck screen appears. This is because the list of equipment types that the program could simulate did not include such a screen. Instead, the double deck screen is simulated via a combination of three units - a wet upper screen with a size of 1-1/2 inches, a wet lower screen with a mesh 1/2 inch, and a blender. The underflow of the double deck screen is the underflow of the lower screen and the overflow is the blend of the overflow from the upper screen and the overflow of the lower screen. Now the coal passing through this screen includes a fraction which is 2 inches by 1/2 inch. Since the screen size 1-1/2 inch falls within this range, some bias in the results might be present. The following will show this.

Page 12 of the user handbook example (p. 165) shows the summary of performance characteristics for the upper screen. In particular, it shows a value of 63.3 for the percent weight of the feed to the underflow. Based on the presentation earlier, (4) shows the formula from which this value is derived.

$$(1-d_s)x100=(1-\exp(-Ax(1-X/ss))x(1-f)+f)x100 \qquad (4)$$

In this equation, A has the value 9.0, as can be seen from Table I-4-3.1. X is the material size. Using the uniformity assumption, X equals the midpoint of the size interval below the mesh size 1.0. The screen mesh size is SS and is equal to 1.50. f is that proportion of the material in the interval greater than the screen size. Its calculation is shown in (5).

$$(2.0-1.5)/(2.0-0.5)=.3333 \qquad (5)$$

Inserting these values in (4) and simplifying gives (6).

$$\begin{aligned}&(1-\exp(-9\times(1-1.0/1.5))\times(1-.3333)+0.3333)\times 100.\\&=(1-\exp(-3)\times 0.6667+0.3333)\times 100.0=(1-0.3665)\times 100.0\\&=0.6335\times 100.0=63.35\end{aligned} \tag{6}$$

The value thus derived agrees with the value in the results of the program. Now it is important to note that all of the material in the underflow is assumed by this algorithm to be 1-1/2 by 1/2 inches in size, however, it is still classified in the program as being 2 inches by 1/2 inch. Any values of average size of material for this fraction will be computed as

$$(2.0+0.5)/2=1.25 \tag{7}$$

and not as (8).

$$(1.5+0.5)/2=1.00 \tag{8}$$

Thus, potential values of d_s or their equivalent for other unit operations for this fraction will be biased.

Fortunately, in the example no such bias is actually generated, since the lower mesh is 1/2 inch. However, in general this is a potential problem of which the reader should be aware.

4.4 Washing

Of the unit operations to be discussed, the most work has been done for washing. Basically, the approach is similar to that used in screening, in that a distribution curve is computed which defines the ratio of material in the input which will go to one output flow. The approach differs from that in screening in the manner in which the distribution curve is derived and in the fact that the washing distribution curve is both size fraction and specific-gravity-fraction dependent.

Considering first the straightforward parts of the approach, a washer is assumed to be a unit which takes one input flow, denoted by the subscript I, and two output flows - a clean output flow, denoted by the subscript C, and a refuse output flow, denoted by the subscript R. It is possible to define a set of values, $d_{s,g}$, called the distributions curves, for the unit which specify the proportion of each specific gravity and size fraction category in the input flow which will go to the clean coal output flow. The derivation of $d_{s,g}$ is discussed later in this part.

Given the values for $d_{s,g}$, the calculations of the values for the output flows are very similar to those given for the screening unit operation. In essence, they are as shown in equations (1) and (1a).

$$F_{C,t,s,g} = d_{s,g} F_{I,t,s,g}$$

$$F_{R,t,s,g} = (1 - d_{s,g}) F_{I,t,s,g}$$

$$C_{C,t,s,g} = C_{I,t,s,g}$$

$$C_{R,t,s,g} = C_{I,t,s,g} \tag{1}$$

$$W_C = \frac{W_I \sum_{s,g} F_{C,1,s,g}}{\sum_{s,g} F_{I,1,s,g}}$$

$$W_R = W_I - W_C$$

If the user supplies a decision variable, D2, representing the percent moisture of the clean output flow then

$$W_C = \frac{D2 \sum_{s,g} F_{C,1,s,g}}{(100 - D2)} \qquad (1a)$$

$$W_R = W_I - W_C$$

Notice again that the characteristic values of the two output flows are identical to each other and to those of the input flow. Thus, washers are assumed to have characteristic invariance.

Turning now to the calculation of the $d_{s,g}$ values, observe that coal washing equipment uses the float-and-sink principle based on the specific gravity differences between coal and its associated impurities which typically have a higher specific gravity. This can be seen very clearly in Figure I-3-1.1 which shows the direct percent ash plotted against specific gravity for the feed to the plant in the example. This figure shows that as the specific gravity increases so does the direct percent ash.

Given the float-sink operation of the washing equipment, as the specific gravity of the material increases the ratio of that material which will go to the clean coal output flow, the float flow, decreases. Figure I-4-4.1 shows a typical distribution curve holding the size variation constant. The crucial value on this curve, insofar as this discussion is concerned, is that of specific gravity corresponding to the y-axis value of 0.50. This value is referred to as the specific gravity of separation. It is at this specific gravity that the material in the input flow is evenly divided between clean coal and refuse. Note that the uniqueness of this value derives from the fact that the curve is monotone decreasing. No two different specific gravities can have the same ratio to clean coal.

The washing unit operation, then, requires a distribution curve to serve as the basis for its implementation. These distribution curves must be supplied by the user much as a curve describing the adjustment factor was required for the screening unit operation. Under one mode, the user simply defines the distribution curves which he has available for the particular piece of washing equipment and the program applies them.

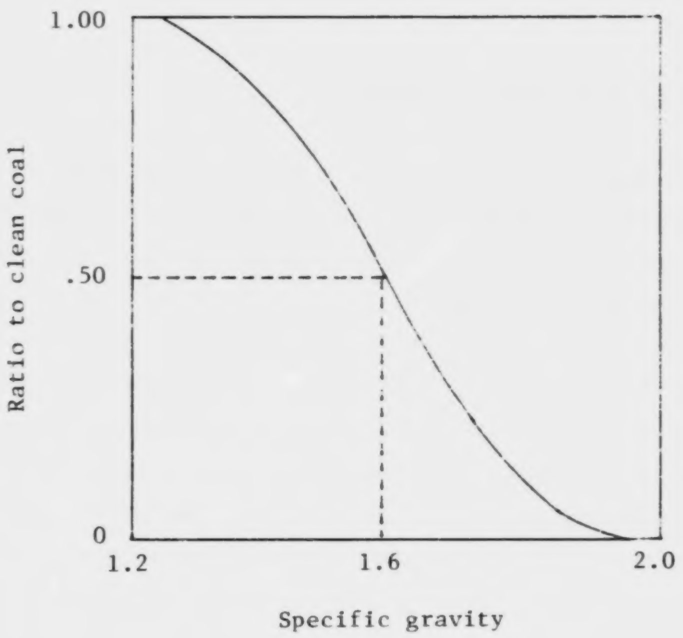

FIGURE I-4-4.1. TYPICAL DISTRIBUTION CURVE

In many cases, however, the user of the program may not have available to him detailed actual distribution curves for the washing equipment to be simulated. In these cases some general description of the operation of particular types of washing equipment is needed. Such general descriptions have been prepared by the Bureau of Mines and are discussed in Gottfried(7) and Gottfried and Jacobsen(8). The following subparts discuss the original formulation of generalized distribution curves and the modification of them to c-generalized distribution curves as used in the current version of CPSM4.

4.4.1 Generalized Distribution Curves

As was shown earlier, if the distribution curves are known for a given unit, then the representations of the two output flows for a given input flow are easy to calculate. The problem is that the curves are highly variable relative both to the size of the material and to the specific gravity of separation desired. The approach taken was to represent a set of distribution curves derived empirically in a manner independent of the specific gravity of separation. The ratio to clean coal is expressed not in terms of specific gravity, but rather in terms of the ratio of specific gravity by the specific gravity of separation. The basic assumption made in the formulation of the generalized distribution curves is that all of the variation in the distribution curves observed for a given type of washing unit can be explained via a variation in the specific gravity of separation for those curves.

Table I-4-4.1 shows a set of distribution curves taken from Deurbrouck and Hudy(9). It was based on the data from which Gottfried and Jacobsen(8) computed the values for the generalized distribution curves. This table also includes the values of reduced specific gravity calculated for each curve. These values of reduced specific gravity were computed by dividing the column marked "specific gravity" by the specific gravity of separation for the size fraction. Given these values of reduced specific gravity and of percent to clean, Gottfried and Jacobsen(8) plotted them in scatter diagram form. The actual generalized curves were then estimated by hand drawing curves through the scatter diagrams.

TABLE I-4-4.1. DISTRIBUTION CURVES AND GENERALIZED DISTRIBUTION CURVES FOR 1/4 INCH BY 8 MESH SIZE FRACTION FOR DENSE-MEDIUM CYCLONE WASHERS

		Plant A		Plant B		Plant C		Plant D		Plant E		Plant F		Plant G	
Specific gravity fraction	Specific gravity	Reduced specific gravity	Percent to clean	Reduced specific gravity	Percent to clean	Reduced specific gravity	Percent to clean	Reduced specific gravity	Percent to clean	Reduced specific gravity	Percent to clean	Reduced specific gravity	Percent to clean	Reduced specific gravity	Percent to clean
Float-1.28	1.27	--	--	.847	100.0	--	--	.888	99.4	.864	100.0	--	--	--	--
1.28-1.30	1.29	--	--	.860	99.9	--	--	.902	99.4	.876	99.7	--	--	--	--
Float-1.30	1.28	.826	99.9	--	--	.837	99.9	--	--	--	--	.908	99.1	.877	95.8
1.30-1.35	1.325	.855	99.8	.883	100.0	.866	99.8	.927	98.5	.901	99.7	.940	99.0	.908	95.5
1.35-1.40	1.375	.887	99.8	.917	99.9	.899	99.4	.962	92.1	.935	99.5	.975	90.6	.942	90.7
1.40-1.45	1.425	.919	98.2	.950	98.5	.931	98.9	.997	57.1	.969	95.5	1.011	37.3	.976	75.0
1.45-1.50	1.475	.952	95.5	.983	74.4	.964	93.8	1.031	16.6	1.003	49.7	1.046	7.7	1.010	37.6
1.50-1.60	1.55	1.000	49.9	1.033	19.3	1.013	33.2	1.084	3.2	1.054	8.2	1.099	4.9	1.062	13.5
1.60-1.70	1.65	1.065	5.7	1.100	0.0	1.0[illegible]	1.6	1.154	2.1	1.122	0.4	1.170	0.0	1.130	5.6
1.70-1.80	1.75	1.129	0.0	1.167	0.0	1.144	0.0	1.224	0.0	1.190	0.0	1.241	0.0	1.119	3.7
Specific gravity of separation for fraction		1.55		1.50		1.53		1.43		1.47		1.41		1.46	
Specific gravity of separation of composite		1.55		1.51		1.53		1.42		1.48		1.42		1.45	

There is one problem associated with the use of the generalized curves which relates to the fact that separate generalized distribution curves were estimated for the various size fractions available. It was this problem which eventually led to the formulation used in the present version of CPSM4 of c-generalized distribution curves. This current formulation will be discussed in the next subpart.

In essence, the decision variable to be used with the washers is the specific gravity of separation desired for the composite separation to clean coal. But the specific gravity of separation for the composite does not typically equal the specific gravity of separation for some size fraction within that composite. This fact is illustrated on the bottom two rows of Table I-4-4.1 which show the specific gravity of separation for the size fraction and for the composite that contained that fraction. Some technique then is needed to estimate the desired specific gravity of separation for individual size fraction specific distribution curves based on the desired composite specific gravity of separation specified as the decision variable for the unit.

The approach taken by Gottfried and Jacobsen(8) was to estimate for any given size fraction s, the ratio

$$r_s = \rho_s/\rho_c \qquad (2)$$

where ρ_s is the specific gravity of separation for the s size fraction and ρ_c is the composite specific gravity of separation. These estimates were made from the same data as was used to estimate the generalized curves.

A desired specific gravity of separation $\rho_{d,s}$ for a size fraction s can then be computed from the desired composite specific gravity of separation $\rho_{d,c}$ by the equation shown in (3).

$$\rho_{d,s} = \rho_{d,c} \cdot r_s \qquad (3)$$

Given the above, the distribution curve value $d_{s,g}$ for a given size fraction s and a given specific gravity fraction g with specific gravity ρ_g can be computed from the generalized curve G_s as shown in (4).

$$d_{s,g} = G_s(\rho_g/(\rho_{d,c} \cdot r_s)) \qquad (4)$$

Each type of washing unit was represented by two sets of values -- the values defining the generalized curves for each size fraction and the ratios for computing the size fraction specific gravities of separation.

4.4.2 C-Generalized Distribution Curves

From the standpoint of the current version of program CPSM4, the calculation of $d_{s,g}$ as shown in equation (4) is objectionable for three reasons. First, it is computationally inefficient since it requires a multiplication by the value r_s before a value can be obtained from the function G_s. Ideally, the argument to G_s should simply be $\rho_g/\rho_{d,c}$. Second, it is inefficient from the standpoint of storage since it requires the additional storage of the values for r_s. Third, the use of the r_s values requires that they too be estimated from the data in addition to the generalized curves themselves.

The approach taken in the current version, then, was to compute the reduced specific gravity based not on the specific gravity of separation for the individual size fractions but rather on the composite specific gravity. The dependence of the function argument upon the size fraction was transferred to the fraction itself by scaling, thus producing identical results while simplifying the form of the argument. The curves so formed will be referred to as c-generalized (c for composite) curves. Using a c-generalized curve, the calculation of the values for $d_{s,g}$ is simply as shown in (5).

$$d_{s,g} = G_s^c\ (\rho_g/\rho_{d,c}) \tag{5}$$

Here G_s^c represents the c-generalized curve for the size fraction s. This formulation is more efficient computationally, requires less storage, and is easier to estimate.

Actually, the c-generalized approach makes a somewhat different empirical assumption than does the generalized one. The basic assumption made in the formulation of c-generalized distribution curves is that all of the variation in the distribution curves for a given type of washing unit can be explained via a variation in the composite specific gravity of separation for those curves. There appears to be no intuitive or logical reason to choose the one assumption over the other. Selection could be made based on the statistical goodness of fit derived for a curve based on the generalized approach versus the c-generalized approach. Unfortunately, the generalized curves were not obtained via a statistical technique; therefore, no such comparison could be made. Ultimately, the c-generalized approach was taken simply because it is simpler and more efficient from a programming standpoint.

From a logistics standpoint, the only other problem associated with reformulating the approach to generalizing the distribution curves derived from the desire to maintain all other assumptions made by Gottfried and Jacobsen(8) in the new formulation. If this could be done, then the c-generalized curves would produce values for $d_{s,g}$ identical to those produced by the generalized ones. To accomplish this, the c-generalized curves were computed directly from the values specified for the generalized curves simply by multiplying the x-axis values of the generalized curve by the specified value of r_s for that curve.

To show that the curves thus produced do in fact take $\rho_g/\rho_{d,c}$ as an argument and do in fact produce the same results as the curves which take $\rho_g/(\rho_{d,c} \cdot r_s)$ as an argument, requires the introduction of the notion of interpolation. Values for functions at arbitrary points are computed from a finite set of specified points via an interpolation calculation. The simplest type of interpolation is linear interpolation. Equation (6) shows the formula for linear interpolation.

$$Y = ((Y_{i-1}-Y_i) \cdot (X_i-X)/(X_i-X_{i-1})) + Y_i \qquad (6)$$

where Y is the desired functional value

X is the specified argument

i is the index of the specified x point immediately greater than or equal to X

i-1 is the index of the specified x point immediately less than X.

Now for any given ρ_g, r_s, and $\rho_{d,c}$ the generalized curve would give equation (7).

$$\begin{aligned} Y &= ((Y_{i-1}-Y_i) \cdot (X_i-\rho_g/(r_s \cdot \rho_{d,c}))/(X_i-X_{i-1})) + Y_i \\ &= ((Y_{i-1}-Y_i) \cdot (X_i/(X_i-X_{i-1}) - \rho_g/(\rho_{d,c} \cdot r_s \cdot (X_i-X_{i-1}))) + Y_i \end{aligned} \qquad (7)$$

The c-generalized curve computed from the generalized one would give the identical equation (8).

$$\begin{aligned} Y &= ((Y_{i-1}-Y_i) \cdot (X_i \cdot r_s - \rho_g/\rho_{d,c}))/(X_i \cdot r_s - X_{i-1} \cdot r_s)) + Y_i \qquad (8) \\ &= ((Y_{i-1}-Y_i) \cdot (X_i \cdot r_s/(X_i \cdot r_s-X_{i-1} \cdot r_s) - \rho_g/(\rho_{d,c} \cdot (X_i \cdot r_s-X_{i-1} \cdot r_s))) + Y_i \\ &= ((Y_{i-1}-Y_i) \cdot (X_i/(X_i-X_{i-1}) - \rho_g/(\rho_{d,c} \cdot r_s \cdot (X_i-X_{i-1}))) + Y_i \end{aligned}$$

Therefore, the two formulations produce identical results under linear interpolation. To show the same result for other types of interpolation, such as Lagrangian which is actually used, is straightforward though tedious; therefore, it will not be done here.

The actual values to be used for the c-generalized curves for the five types of washing equipment for which estimates were originally made by Gottfried and Jacobsen(8) are shown in the following five tables, I-4-4.2 through I-4-4.6.

TABLE I-4-4.2. C-GENERALIZED CURVE DATA FOR CONCENTRATING TABLE BY SIZE FRACTION

Plus 1/2 inch		1/4 inch by 8 mesh		8 mesh by 14 mesh		14 mesh by 28 mesh		28 mesh by 48 mesh		48 mesh by 100 mesh		Minus 100 mesh	
c-Reduced specific gravity	Ratio to clean	c-Reduced specific gravity	Ratio to clean	c-Reduced specific gravity	Ratio to clean	c-Reduced specific gravity	Ratio to clean	c-Reduced specific gravity	Ratio to clean	c-Reduced specific gravity	Ratio to clean	c-Reduced specific gravity	Ratio to clean
.8181	1.000	.8290	1.000	.7646	1.000	.7362	1.000	.7515	1.000	.7479	1.000	.7345	1.000
.8694	.993	.8509	.997	.82[illegible]9	.997	.7954	.993	.7813	.994	.8122	.977	.7757	.998
.9793	.987	.8648	.993	.8425	.994	.8051	.991	.8018	.987	.8798	.941	.8242	.992
.8892	.978	.8747	.987	.8620	.981	.8245	.983	.8306	.968	.9250	.908	.8775	.981
.9030	.960	.8847	.977	.8766	.960	.8391	.972	.8635	.932	.9723	.862	.9211	.969
.9129	.940	.8966	.963	.8961	.920	.8488	.962	.8861	.900	1.0017	.823	.9696	.947
.9218	.920	.9045	.948	.9058	.880	.8633	.939	.9252	.800	1.0332	.758	1.0132	.919
.9267	.900	.9314	.900	.9497	.635	.8827	.887	1.0280	.500	1.1280	.500	1.0326	.900
.9416	.800	.9433	.800	.9740	.500	.9021	.817	1.1514	.200	1.1573	.420	1.0908	.800
.9586	.690	.9642	.675	1.0227	.279	.9700	.500	1.1925	.135	1.1731	.375	1.2120	.500
.9880	.500	.9940	.500	1.0519	.148	1.0379	.246	1.2336	.099	1.2171	.300	1.2847	.400
1.0186	.300	1.0288	.300	1.0665	.100	1.0573	.195	1.2953	.066	1.2634	.237	1.3623	.339
1.0532	.080	1.0387	.240	1.0909	.068	1.0864	.145	1.3364	.052	1.3762	.100	1.4544	.292
1.0581	.060	1.0626	.180	1.1201	.046	1.1252	.103	1.3981	.040	1.3987	.080	1.5998	.243
1.0670	.043	1.0835	.099	1.1688	.025	1.1689	.073	1.6448	.026	1.4326	.060	1.6968	.219
1.0769	.033	1.1093	.060	1.2272	.018	1.2853	.040	1.8504	.021	1.4890	.040	1.9392	.177
1.0868	.026	1.1332	.040	1.6558	.000	1.4308	.015	2.0560	.020	1.5566	.030	2.4240	.120
1.0977	.023	1.1610	.026	1.7532	.000	1.6189	.000	2.1074	.020	2.2560	.020	2.4846	.120
1.2844	.011	1.1928	.018	1.8506	.000	1.7460	.000	2.1588	.020	2.3124	.020	2.5452	.120
1.4820	.000	1.5467	.000	1.9480	.000	1.9400	.000	2.2102	.020	2.3688	.020	2.6058	.120

TABLE I-4-4.3. C-GENERALIZED CURVE DATA FOR DENSE MEDIUM VESSEL BY SIZE FRACTION

Plus 4 inches		4 inches by 2 inches		2 inches by 1 inch		1 inch by 1/2 inch		Minus 1/2 inch	
c-Reduced specific gravity	Ratio to clean	c-Reduced specific gravity	Ratio to clean	c-Reduced specific gravity	Ratio to clean	c-Reduced specific gravity	Ratio to clean	c-Reduced specific gravity	Ratio to clean
.9399	1.000	.9104	1.000	.8719	1.000	.7828	1.000	.8434	1.000
.9457	.997	.9221	.989	.8737	.993	.9322	.993	.8629	.997
.9487	.993	.9320	.977	.9205	.978	.9474	.987	.8887	.991
.9496	.980	.9437	.959	.9394	.962	.9595	.976	.9207	.975
.9612	.700	.9506	.945	.9553	.940	.9666	.954	.9485	.956
.9690	.500	.9584	.919	.9682	.906	.9757	.860	.9712	.931
.9787	.260	.9653	.800	.9731	.844	.9908	.700	.9867	.899
.9903	.012	.9810	.500	.9811	.700	1.0100	.500	.9898	.880
.9923	.006	.9859	.400	.9930	.500	1.0353	.247	1.0104	.690
.9932	.003	.9957	.210	1.0059	.288	1.0555	.046	1.0310	.500
.9961	.000	1.0045	.040	1.0208	.068	1.0656	.025	1.0527	.300
1.0010	.000	1.0075	.027	1.0258	.048	1.0807	.013	1.0640	.208
1.0078	.000	1.0153	.013	1.0357	.030	1.0938	.007	1.0722	.160
1.0175	.000	1.0242	.005	1.0476	.015	1.1161	.001	1.0826	.120
1.0271	.000	1.0359	.000	1.0575	.009	1.1272	.000	1.1083	.071
1.0368	.000	1.0369	.000	1.0774	.000	1.1282	.000	1.1393	.040
1.0465	.000	1.0379	.000	1.0784	.000	1.1292	.000	1.1702	.020
1.0562	.000	1.0389	.000	1.0794	.000	1.1302	.000	1.2114	.006
1.0659	.000	1.0399	.000	1.0804	.000	1.1312	.000	1.2372	.002
1.0756	.000	1.0408	.000	1.0814	.000	1.1322	.000	1.2753	.000

TABLE I-4-4.4. C-GENERALIZED CURVE DATA FOR DENSE MEDIUM CYCLONE BY SIZE FRACTION

Plus 1/2 inch		1/2 inch by 3/8 inch		3/8 inch by 1/4 inch		1/4 inch by 8 mesh		8 mesh by 14 mesh		Minus 14 mesh	
c-Reduced specific gravity	Ratio to Clean	c-Reduced specific gravity	Ratio to clean	c-Reduced specific gravity	Ratio to clean	c-Reduced specific gravity	Ratio to clean	c-Reduced specific gravity	Ratio to clean	c-Reduced specific gravity	Ratio to clean
.9413	1.000	.9069	1.000	.8939	1.000	.8761	1.000	.8458	1.000	.8076	1.000
.9502	.997	.9148	.997	.9315	.992	.8891	.999	.8763	.997	.8336	.996
.9602	.990	.9297	.991	.9415	.987	.8991	.998	.8967	.994	.8701	.988
.9652	.983	.9396	.985	.9474	.982	.9141	.996	.9181	.986	.8857	.983
.9681	.978	.9475	.978	.9543	.973	.9441	.988	.9426	.969	.9378	.958
.9691	.970	.9644	.970	.9563	.968	.9590	.979	.9599	.951	.9639	.937
.9950	.500	.9574	.952	.9712	.760	.9670	.965	.9731	.928	.9795	.917
1.0179	.066	.9742	.940	.9910	.500	.9790	.800	.9782	.914	.9899	.897
1.0199	.054	.9890	.500	1.0059	.280	.9990	.500	.9823	.896	.9951	.880
1.0229	.040	1.0088	.220	1.0217	.056	1.0140	.320	.9986	.720	1.0160	.710
1.0278	.030	1.0216	.040	1.0237	.044	1.0300	.120	1.0190	.500	1.0420	.500
1.0358	.020	1.0236	.029	1.0277	.034	1.0390	.088	1.0496	.194	1.0785	.206
1.0448	.012	1.0286	.019	1.0386	.020	1.0539	.062	1.0567	.156	1.0889	.130
1.0547	.006	1.0385	.008	1.0524	.010	1.0739	.040	1.0771	.100	1.0941	.110
1.0647	.002	1.0513	.002	1.0653	.005	1.0989	.024	1.0954	.073	1.1045	.089
1.0725	.000	1.0632	.000	1.0812	.000	1.1289	.010	1.1229	.050	1.1358	.055
1.0736	.000	1.0642	.000	1.0822	.000	1.1389	.006	1.1617	.029	1.1723	.036
1.0746	.000	1.0652	.000	1.0832	.000	1.1578	.000	1.1973	.016	1.3546	.014
1.0756	.000	1.0661	.000	1.0842	.000	1.1588	.000	1.2452	.006	1.5703	.000
1.0766	.000	1.0671	.000	1.0851	.000	1.1598	.000	1.3247	.000	1.5713	.000

TABLE I-4-4.5. C-GENERALIZED CURVE DATA FOR HYDRO CYCLONE BY SIZE FRACTION

Minus 4 mesh		4 mesh by 8 mesh		8 mesh by 14 mesh		14 mesh by 28 mesh		28 mesh by 65 mesh		65 mesh by 100 mesh		Minus 100 mesh	
c-Reduced specific gravity	Ratio to clean	c-Reduced specific gravity	Ratio to clean	c-Reduced specific gravity	Ratio to clean	c-Reduced specific gravity	Ratio to clean	c-Reduced specific gravity	Ratio to clean	c-Reduced specific gravity	Ratio to clean	c-Reduced specific gravity	Ratio to clean
.5670	1.000	.5052	1.000	.3875	1.000	.2868	1.000	.3491	1.000	.5635	1.000	.6810	1.000
.5994	.991	.5894	.962	.4520	.981	.3633	.989	.4565	.995	.6127	.999	.8513	.985
.6383	.965	.6652	.908	.4951	.965	.4589	.968	.5553	.983	.6738	.994	1.1577	.890
.6699	.930	.7241	.835	.5467	.939	.5507	.941	.6659	.954	.8441	.954	1.1781	.876
.6958	.890	.7578	.768	.5984	.905	.5908	.925	.8055	.886	.9508	.910	1.1918	.863
.7128	.857	.7999	.646	.7103	.971	.6682	.881	.8485	.858	.9844	.891	1.2054	.844
.7371	.793	.8420	.500	.7964	.678	.7648	.806	.9022	.814	.0096	.873	1.3620	.500
.7476	.758	.8715	.400	.8352	.595	.8528	.713	.9419	.769	1.0479	.838	1.3892	.440
.7630	.702	.9052	.298	.8610	.500	.8986	.640	.9612	.735	1.0791	.793	1.4097	.400
.8100	.500	.9262	.247	.9041	.332	.9560	.500	1.0740	.500	1.1990	.500	1.4369	.361
.8262	.440	.9649	.175	.9213	.277	1.0267	.326	1.3210	.094	1.2482	.381	1.4710	.321
.8570	.339	1.0045	.115	.9514	.221	1.0516	.279	1.3339	.078	1.2913	.313	1.4982	.295
.9185	.153	1.0390	.070	1.0117	.14	1.1013	.200	1.3694	.049	1.3549	.246	1.5731	.230
.9437	.109	1.0794	.048	1.0616	.095	1.1453	.140	1.4016	.033	1.5143	.212	1.6072	.205
.9769	.074	1.1687	.029	1.1064	.067	1.2237	.063	1.4306	.024	1.5587	.093	1.6276	.193
1.0368	.034	1.3135	.012	1.1451	.053	1.2638	.041	1.4499	.020	1.6103	.069	1.6548	.179
1.1057	.017	1.3977	.004	1.2269	.035	1.3002	.030	1.5057	.017	1.6546	.053	1.7025	.157
1.1988	.007	1.5139	.000	1.3561	.017	1.7151	.011	1.6916	.012	1.8117	.021	1.7910	.123
1.2798	.003	1.5148	.000	1.5068	.003	2.2179	.000	2.0406	.000	1.9184	.009	1.8728	.100
1.3770	.000	1.5156	.000	1.6359	.000	2.2275	.000	2.0513	.000	2.0383	.000	1.8741	.100

TABLE I-4-4.6. C-GENERALIZED CURVE DATA FOR SINGLE-STAGE BAUM JIG BY SIZE FRACTION

Plus 3 inches		3 inches by 1-5/8 inches		1-5/8 inches by 1/2 inch		1/2 inch by 1/4 inch		1/4 inch by 8 mesh		8 mesh by 14 mesh		Minus 14 mesh	
c-Reduced specific gravity	Ratio to clean	c-Reduced specific gravity	Ratio to clean	c-Reduced specific gravity	Ratio to clean	c-Reduced specific gravity	Ratio to clean	c-Reduced specific gravity	Ratio to clean	c-Reduced specific gravity	Ratio to clean	c-Reduced specific gravity	Ratio to clean
.8432	1.000	.8463	1.000	.8056	1.000	.7999	1.000	.7093	1.000	.7653	1.000	.7656	1.000
.8488	.997	.8529	.998	.8328	.997	.8248	.997	.7467	.995	.7891	.996	.7968	.998
.8526	.987	.8606	.990	.8570	.991	.8486	.989	.7904	.985	.8086	.990	.8385	.990
.8601	.979	.9015	.907	.8882	.977	.8767	.971	.8258	.970	.8302	.980	.8880	.975
.8836	.880	.9120	.869	.8993	.967	.9016	.945	.8528	.952	.8453	.969	.9374	.948
.9137	.699	.9225	.814	.9053	.955	.9156	.922	.8798	.931	.8691	.937	.9635	.925
.9400	.500	.9292	.750	.9637	.699	1.0397	.681	.8986	.899	.9275	.840	1.0156	.873
.9739	.223	.9530	.500	1.0070	.500	1.0810	.500	.9568	.733	.9751	.739	1.1497	.702
.9908	.080	.9730	.300	1.0523	.299	1.1761	.275	1.0400	.500	1.0810	.500	1.3020	.500
.9936	.064	.9787	.250	1.0916	.131	1.1880	.255	1.1055	.366	1.1264	.397	1.3619	.422
.9983	.047	.9892	.201	1.0976	.113	1.2096	.229	1.1710	.255	1.1448	.369	1.3853	.400
1.0058	.032	.9987	.159	1.1087	.093	1.2453	.197	1.1960	.217	1.1718	.337	1.4244	.376
1.0152	.019	1.0159	.129	1.1248	.075	1.2964	.169	1.2158	.194	1.2129	.397	1.4921	.343
1.0293	.006	1.0340	.097	1.1409	.065	1.3318	.145	1.2501	.168	1.2734	.250	1.6171	.298
1.0340	.003	1.0454	.083	1.1651	.057	1.4118	.115	1.2958	.142	1.4745	.119	1.7421	.267
1.0406	.000	1.0559	.075	1.2739	.034	1.5329	.086	1.3624	.144	1.5372	.089	1.9400	.229
1.0415	.000	1.1131	.035	1.4551	.015	1.6788	.061	1.4414	.088	1.6129	.064	2.1848	.193
1.0425	.000	1.1741	.000	1.7522	.000	1.8377	.040	1.5558	.062	1.7318	.038	2.6040	.143
1.0440	.000	1.1750	.000	1.7532	.000	1.8388	.040	1.7763	.028	1.8982	.018	2.6043	.143
1.0449	.000	1.1760	.000	1.7542	.000	1.8399	.040	2.0800	.000	2.0539	.010	2.6066	.143

4.5 Two-Stage Washing

The two-stage washing unit operation is closely related to the single-stage operation. It differs only in that three output flows rather than two are produced. The three output flows will be referred to as clean (denoted with a subscript C), middling (denoted with a subscript M), and refuse (denoted with a subscript R). The mathematical approach differs in that there are two sets of distribution curves used - $d^C_{s,g}$, the proportion of each specific gravity and size fraction category in the feed which goes to clean, and $d^M_{s,g}$, the proportion of each category in the feed which goes to middling.

Given the values for $d^C_{s,g}$ and $d^M_{s,g}$ the calculations of the values for the output flows are very similar to those given for the single-stage operation. They are shown in the equations in (1) and (2).

$$F_{C,t,s,g} = d^C_{s,g} F_{I,t,s,g}$$

$$F_{M,t,s,g} = d^M_{s,g} F_{I,t,s,g}$$

$$F_{R,t,s,g} = (1 - d^C_{s,g} - d^M_{s,g}) F_{I,t,s,g}$$

$$C_{C,t,s,g} = C_{I,t,s,g}$$

$$C_{M,t,s,g} = C_{I,t,s,g} \tag{1}$$

$$C_{R,t,s,g} = C_{I,t,s,g}$$

$$W_C = \frac{W_I \sum_{s,g} F_{C,1,s,g}}{\sum_{s,g} F_{I,1,s,g}}$$

$$W_M = \frac{W_I \sum_{s,g} F_{M,1,s,g}}{\sum_{s,g} F_{I,1,s,g}}$$

$$W_R = W_I - W_C - W_M$$

These equations make the percent moisture levels of each of the three output flows equal to those of the input flow. To modify this the user may specify two decision variables, D2 and D3, representing the percent moisture of the clean flow and the percent moisture of the middling flow, respectively. Then

$$
\begin{aligned}
W_C &= \frac{D2 \sum_{s,g} F_{C,1,s,g}}{(100 - D2)} \\
W_M &= \frac{D3 \sum_{s,g} F_{M,1,s,g}}{(100 - D3)} \qquad (2) \\
W_R &= W_I - W_C - W_M
\end{aligned}
$$

Note, as before, that the characteristic values of the three output flows are identical to each other and to those of the input flow. Thus, two-stage washers are assumed to have characteristic invariance.

The values for the distribution curves, $d_{s,g}^{C}$ and $d_{s,g}^{M}$, are the same as they were for the washers. They were originally defined in Gottfried and Jacobsen(8) as generalized distributions based on reduced specific gravity computed from the decision variable value for specific gravity of separation. In the present version of the program, they may either be explicitly defined or may be derived generally from c-generalized distribution curves.

The only two-stage washing equipment type for which c-generalized curve estimates are available is the two-stage baum jig. The c-generalized curve values of $d_{s,g}^{C}$ for the two-stage baum jig are identical to those given for $d_{s,g}$ for the single stage baum jig in the previous part on Table I-4-4.6. The c-generalized curve values for $d_{s,g}^{M}$ for the two-stage baum jig are given in Table I-4-5.1. It should be observed that the original formulation for the middling stream from the two-stage baum jig was considerably more complex than the present one. The values in Table I-4-5.1 were derived from two independent generalized curves in the original version of the program through

TABLE I-4-5.1. C-GENERALIZED MIDDLING CURVE DATA FOR TWO-STAGE BAUM JIG BY SIZE FRACTION

Plus 3 inches		3 inches by 1-5/8 inches		1-5/8 inches by 1/2 inch		1/2 inch by 1/4 inch		1/4 inch by 8 mesh		8 mesh by 14 mesh		Minus 14 mesh	
c-Reduced specific gravity	Ratio to middling	c-Reduced specific gravity	Ratio to middling	c-Reduced specific gravity	Ratio to middling	c-Reduced specific gravity	Ratio to middling	c-Reduced specific gravity	Ratio to middling	c-Reduced specific gravity	Ratio to middling	c-Reduced specific gravity	Ratio to middling
.8296	.0000	.8249	.0000	.8173	.0000	.7948	.0000	.7187	.0000	.7970	.0000	.8016	.0000
.8345	.0017	.8435	.0000	.8452	.0021	.8301	.0000	.7399	.0030	.8192	.0050	.8350	.0050
.8538	.0101	.8719	.0166	.8731	.0095	.8437	.0040	.7632	.0070	.8369	.0120	.8631	.0150
.8667	.0216	.8927	.0426	.9009	.0245	.8518	.0150	.7950	.0150	.8480	.0200	.9325	.0530
.8850	.0507	.9058	.0658	.9242	.0619	.9185	.0799	.8247	.0270	.8568	.0310	1.0154	.1030
.8957	.0922	.9190	.0896	.9404	.1097	.9560	.1354	.8533	.0430	.9686	.2410	1.0568	.1350
.9086	.1906	.9408	.1837	1.0542	.3734	1.0342	.2679	.8798	.0650	1.1070	.5000	1.1075	.1750
.9301	.3315	.9638	.3331	1.1610	.4266	1.1340	.3680	.8946	.0840	1.1646	.6000	1.2318	.3590
.9709	.4707	1.0940	.4573	1.1749	.4258	1.1884	.3883	.9031	.1010	1.2077	.6590	1.3360	.5000
.9988	.5475	1.1224	.4425	1.2028	.4189	1.2100	.3834	.9964	.3400	1.2553	.7090	1.3894	.5510
1.0267	.5645	1.1618	.4314	1.2376	.4020	1.2599	.3576	1.0600	.5000	1.3173	.7590	1.4656	.5950
1.0740	.5000	1.2078	.4000	1.3050	.3738	1.3290	.3304	1.1024	.5770	1.3981	.8050	1.5711	.6770
1.1234	.4370	1.2800	.3620	1.3862	.3439	1.3926	.3168	1.1702	.6870	1.5155	.8500	1.7128	.6790
1.1814	.3800	1.4003	.3090	1.5441	.2950	1.4878	.3011	1.1989	.7170	1.6516	.8830	1.8811	.7170
1.2297	.3450	1.5863	.2430	1.8274	.2274	1.5574	.2904	1.2444	.7480	1.8277	.9050	2.0775	.7520
1.2845	.3160	1.9003	.1490	2.3220	.1188	1.8144	.2583	1.3123	.7860	2.0491	.9200	2.6720	.8400
1.3898	.2730	2.1880	.0680	2.3232	.1188	2.0412	.2355	1.3685	.8090	2.2140	.9250	2.6733	.8400
1.5347	.2330	2.1891	.0680	2.3243	.1188	2.2680	.2036	1.4946	.8510	2.2151	.9250	2.6747	.8400
1.6840	.1980	2.1902	.0680	2.3255	.1188	2.2691	.2034	1.6960	.8910	2.2.62	.9250	2.6760	.8400
2.0406	.1320	2.1913	.0680	2.3266	.1188	2.5678	.1748	2.1200	.9370	2.2173	.9250	2.6773	.8400

a series of relatively complex computations. These are not directly relevant to this discussion and will not, therefore, be discussed here. The point is brought up only because as a result of these transgenerations of two generalized curves into one c-generalized curve, the c-generalized version produces slightly different results than did the original version. These differences do not appear to be significant.

4.6 Froth Flotation

Perhaps the most interesting of the unit operations is the one for froth flotation. As mentioned in Chapter 3 of this section, froth flotation is unique in that the unit operation has the property of characteristic invariance, but does not have the property of characteristic independence. Reviewing these concepts briefly, the above means that though the values of $C_{t,s,g}$ for the output flows are the same as those of the input flows, the determination of the distribution of the material in the output is dependent upon the values of $C_{t,s,g}$ in the input. This topic is expanded in the following discussion.

In the final analysis, the froth flotation unit operation is much like that of the washing unit operation in that it computes a set of values, $d_{s,g}$, called distribution curves which specify the proportion of each specific gravity and size fraction category in the input flow (denoted by a subscript I) which will go to the clean output flow (denoted by a subscript C). The remaining material in the input flow goes to a refuse output flow (denoted by a subscript R). Given the values for $d_{s,g}$, the calculations for the output flows as shown in (1) and (2) below are identical to those for the washing unit operation.

$$
\begin{aligned}
F_{C,t,s,g} &= d_{s,g}\, F_{I,t,s,g} \\
F_{R,t,s,g} &= (1 - d_{s,g})\, F_{I,t,s,g} \\
C_{C,t,s,g} &= C_{I,t,s,g} \qquad\qquad (1) \\
C_{R,t,s,g} &= C_{I,t,s,g} \\
W_C &= \frac{W_I \sum_{s,g} F_{C,1,s,g}}{\sum_{s,g} F_{I,1,s,g}} \\
W_R &= W_I - W_C
\end{aligned}
$$

If the user supplies a decision variable, D1, representing the percent moisture of the clean output flow, then

$$W_C = \frac{D1 \sum_{s,g} F_{C,1,s,g}}{(100 - D1)}$$

$$W_R = W_I - W_C \tag{2}$$

The remainder of this part discusses the derivation of the values for $d_{s,g}$ for the froth flotation unit operation.

The only discussion of this unit operation to date appears in Gottfried, Jacobsen, and Vaillant(1) and states:

> "The overall yield of clean coal is taken as the value of the cumulative weight distribution in the froth flotation feed at a specific gravity of 1.50. Similarly, the overall ash content of the clean coal is taken as the cumulative ash of the feed at a specific gravity of 1.60. Detailed specific gravity analyses of the clean coal and refuse products are obtained by applying to the feed a distribution curve that will produce the '1.50-yield/1.60 ash' product. Sulfur and Btu content of the products are obtained from the distribution curve calculations and may differ from the amounts present in either the 1.50 or 1.60 specific gravity feed level."

This description of the unit operation is a bit complex and can be made more understandable by a specific example.

Flowstream number 17 of the example, shown on page 35 of Appendix A (p. 188), is the input flowstream to the froth flotation cell. Flowstream number 21 of the example, shown on page 45 of Appendix A (p. 198), is the clean output flowstream from the same froth flotation cell. Note that the cumulative weight percent is 66.16 percent for the composite size fraction of the input flow for the specific gravity fraction whose upper bound is 1.50. Also note the cumulative percentage of ash (4.63 percent) for the composite size fraction for the specific gravity fraction whose upper bound is 1.60. Applying the description given earlier then, the yield from the froth flotation cell should be approximately 66.16 percent and the overall percent ash in the clean output flow should be approximately 4.63 percent.

Moving over to flowstream 21, the clean output flow, the overall percent ash is 4.7 percent. This value is the bottommost value in the cumulative percent ash column. Turning to the summary data for Units 13, page 44 of Appendix A (p. 197), the yield percent for the froth flotation cell is 65.7 percent as indicated.

Actually within the program the "1.50 yield/1.60 ash" rule is not applied to the composite flow, but rather is applied to the individual size fractions. The example printouts verify that for each size fraction the relationship described above holds.

The only remaining problem for the froth flotation unit operation then is to produce a distribution curve for each size fraction such that the yield of clean coal for that fraction equals the cumulative weight in the feed at a specific gravity of 1.50 for that size fraction and the ash content of the clean coal in that size fraction equals the cumulative ash of the feed at a specific gravity of 1.60 for that fraction. To accomplish this, the froth flotation unit operation is given access to a set of raw generalized distribution curves--those for the concentrating table. The adjective raw is used to indicate that the adjustment factors and size fractions specification associated with the generalized distribution curves are completely ignored. Table I-4-6.1 shows the actual value for these curves.

To generate a particular distribution curve requires estimating a value of specific gravity of separation and then using it to compute a set of reduced specific gravities. The algorithm itself produces every distribution curve from the seven generalized curves in Table I-4-6.1 for every possible specific gravity of separation between 1.40 and 1.60 in steps of .01, for every size fraction. It then uses that curve which comes closest to producing the desired yield and percent ash.

TABLE I-4-6.1. RAW GENERALIZED DISTRIBUTION CURVES USED FOR FROTH FLOTATION UNIT OPERATION

Reduced specific gravity	Ratio to clean	Reduced specific gravity	Ratio to clean	Reduced specific gravity	Ratio to clean	Reduced specific gravity	Ratio to clean	Reduced specific gravity	Ratio to clean	Reduced specific gravity	Ratio to clean	Reduced specific gravity	Ratio to clean
.828	1.000	.834	1.000	.785	1.000	.759	1.000	.731	1.000	.663	1.000	.606	1.000
.880	.993	.856	.997	.850	.997	.820	.993	.760	.994	.720	.977	.640	.998
.890	.987	.870	.993	.865	.994	.830	.991	.780	.987	.780	.941	.680	.992
.900	.978	.880	.987	.885	.981	.850	.983	.808	.968	.820	.908	.724	.981
.914	.960	.890	.977	.900	.960	.865	.972	.840	.932	.862	.862	.760	.969
.924	.940	.902	.963	.920	.920	.875	.962	.862	.900	.888	.823	.800	.947
.933	.920	.910	.948	.930	.880	.890	.939	.900	.800	.916	.758	.836	.919
.938	.900	.937	.900	.975	.635	.910	.887	1.000	.500	1.000	.500	.852	.900
.953	.800	.949	.800	1.000	.500	.930	.817	1.120	.200	1.026	.420	.900	.800
.970	.690	.970	.675	1.050	.279	1.000	.500	1.160	.135	1.040	.375	1.000	.500
1.000	.500	1.000	.500	1.080	.148	1.070	.246	1.200	.099	1.079	.300	1.060	.400
1.031	.300	1.035	.300	1.095	.100	1.090	.195	1.260	.066	1.120	.237	1.124	.339
1.066	.080	1.045	.240	1.120	.068	1.120	.145	1.300	.052	1.220	.100	1.200	.292
1.071	.060	1.069	.180	1.150	.046	1.160	.103	1.360	.040	1.240	.080	1.320	.243
1.080	.043	1.090	.099	1.200	.025	1.205	.073	1.600	.026	1.270	.060	1.400	.219
1.090	.033	1.116	.060	1.260	.018	1.325	.040	1.800	.021	1.320	.040	1.600	.177
1.100	.026	1.140	.040	1.700	.000	1.475	.015	2.000	.020	1.380	.030	2.000	.120
1.111	.023	1.168	.026	1.800	.000	1.669	.000	2.050	.020	2.000	.020	2.050	.120
1.300	.011	1.200	.018	1.900	.000	1.800	.000	2.100	.020	2.050	.020	2.100	.120
1.500	.000	1.556	.000	2.000	.000	2.000	.000	2.150	.020	2.100	.020	2.150	.120

4.7 Resizing Unit Operations

The three remaining unit operations to be discussed in this chapter are rotary breaking, crushing, and dewatering. All three change the size distribution of the feed stream - a general operation referred to as resizing. Before discussing the specific operations, the general concepts of resizing are discussed. Much of the material is taken from Vaillant(6) and Broadbent and Callcott(10), though the actual approach described here differs from that taken by either of the above.

In essence, there are four distinct processes which can take place during the resizing operation:

(1) Liberation
(2) Selection of breakage
(3) Breakage
(4) Screening.

Various resizing operations differ not only in the mathematical distributions associated with the processes, but also in the manner in which the processes interact in order to achieve the ultimate end. This discussion deals primarily with those processes as separate phenomena. Later parts of this chapter will deal with their interaction as simulated in the two unit operations.

4.7.1 Liberation

The effect of the process of liberation is that daughter particles, all broken from the same parent, do not have the same characteristics as the parent. This does not imply, however, that the composite levels of the various characteristics, often referred to as the mass balance, are not maintained during liberation. Equation (1) states this formally.

$$F \cdot C_t = \sum_{\alpha} F_{\alpha} \cdot C_{t,\alpha} \tag{1}$$

where

F is the total weight of the parent

C_t is the value of characteristic t per weight unit for the parent

α ranges over all daughters

F_{α} is the total weight of the αth daughter

$C_{t,\alpha}$ is the value of characteristic t per weight unit for the αth daughter.

The liberation process is minimally modeled in the rotary breaking unit operation and is ignored in the crushing unit operation. Formally, when liberation is modeled, it is treated as though it preceded the remaining resizing operations. The flow stream is first partitioned into the α partitions and then each partition is resized independently.

4.7.2 Breakage and Selection for Breakage

A breakage process is that process which alters the size of some or all of the particles in an assembly. The selection for breakage process is that process which determines the proportion of particles in the assembly which will undergo breakage. In their implementation within CPSM4, both breakage and selection for breakage assume that all particles formed by the breaking of a larger particle have characteristics identical to that larger particle. Any effects of liberation are treated separately. The proportional breakage of a particle of size Y into particles of size less than X is represented by the function B(X,Y). Broadbent and Calcott(10) hold that

> "differences between coals and between breakage processes are accounted for, not by changes in B(X,Y) which is never altered, but by taking different selection functions."

The precise form of the breakage function proposed by the above is shown in (2) below.

$$B(X,Y) = (1 - e^{-X/Y})/(1 - e^{-1}) \qquad (2)$$

The denominator of this function is, of course, a constant and is equal to 0.63212. This breakage function is used by Vaillant(6) and in the program to account for all of the breakage in the rotary breaker and some of it in the crusher. Each crusher type is assigned its own breakage function in addition. This is discussed in Part 4.9. The breakage that occurs in a dewatering device is discussed in 4.7.4.

4.7.3 Screening

The final process in the simulation of the rotary breakers and crushers is screening. Once particles have been broken, they may or may not be eligible for another pass through the selection and breakage processes. This screening process is implemented using the same type of equation used for the screens.

4.7.4 Prebreakage

The mathematics underlying the operation of dewatering is concerned mainly with the breakage that occurs as a secondary effect. To allow for the possibility of secondary breakage during unit operations other than dewatering, the secondary breakage is treated as a separate unit operation which is performed prior to the primary unit operation in which no breakage takes place.

The formulation of this secondary breakage or prebreakage of the input flow to a unit is similar in part to that of breakage described in 4.7.2 above. The basic principle is the concept of selection in which it is supposed that any breakage process may be described by first defining the probability of breakage of particles of each of the sizes involved, and then considering the size distribution of all of the particles, both broken and unbroken. The breakage function used is that of Broadbent and Callcott(10).

$$B(X,Y) = (1 - e^{-X/Y})/(1 - e^{-1}) \qquad (1)$$

where B(X,Y) is the fraction of coal of initial size Y that is broken below size X. The coal is selected for breakage by assuming that a certain fraction, π_i, of the coal in size fraction i is to be broken.

A breakage matrix, b, can be obtained from the breakage function and the grade sizes of the feed; the i-jth element of b is the proportion of the feed which was in the jth size fraction before breakage and is in the ith size fraction in the breakage product. To allow for more severe breakage, powers of the breakage matrix may be used. We assume breakage according to b^K where the integer $K \geq 1$. Then the prebreakage equations are

$$F_{O,t,s,g} = F_{I,t,s,g} (1 - \pi_s) + \sum_{s'=1}^{s} F_{I,t,s',g} \pi_{s'} b^K_{ss'}, \qquad (2)$$

where the feed to the unit is denoted by subscript I and the flow after prebreakage is denoted by subscript O.

4.8 Rotary Breaking

The unit operation for rotary breaking is difficult to describe in equation form. It will, therefore, be presented as a procedure, in a series of steps. The basic decision variables for the rotary breaking unit operation are the length of the drum in feet, the diameter of the drum in feet, and the size of the drum opening in inches. In addition, the user must define a series of empirical constants when he defines the rotary breaking equipment type. These constants are specified in the following discussion.

The first step is to compute the number of falls that the streams will undergo in the breaker and the height of each fall. The number of falls equals the length of the breaker divided by a constant 1.3; while the height is computed by multiplying the diameter by the constant 0.75. Both of these constants are specified on the equipment type definition.

The second step is to compute the probabilities that material will not pass through the holes of the breaker. This is computed using the standard screening equation.

$$pr(ss,ps) = \begin{cases} 1.0 \text{ if } ps \geq ss \\ e^{-A(ss)(1-ps/ss)} \text{ if } ps < ss \end{cases} \qquad (1)$$

where

pr is the probability of not passing through the hole

ss is the hole size

ps is the particle

A is a constant based on the hole size

The value of A is 40 if the hole size is less than or equal to 7 inches, otherwise it equals 50. These constants are all specified in the equipment inventory.

The third step is to liberate the rock and coal streams from the feed. The unit operation assumes that only the highest specific gravity fraction in each size fraction contains any rocks. The weight of these rocks is assumed to equal the weight of ash in the next to highest specific gravity fraction. The rocks are assumed to contain sulfur and to have no Btu content.

At this point the two streams - coal and rock - are treated separately. Each takes the number of falls computed above. The material is selected for breakage using a selection function which is a function of the fall number. The rock and coal selection distributions are specified separately. For rocks, the first fall has a selection value of .005; while the remaining falls have values of 0.0. Thus, the rocks undergo little breakage. The first 12 falls of the coal have a selection factor of 0.20. The factor is 0.08 for the next 12, 0.06 for the next 12, and 0.05 for the remaining falls. The breakage function used is the general one given earlier. After each fall, some material passes through the holes and some does not. This is calculated via the pr values calculated earlier.

4.9 Crushing

The crushing unit operation actually consists of three separate procedures. The material in the flow is divided into three fractions depending on its size as follows:

(1) The material larger than the crushing zone
(2) The material in the crushing zone
(3) The material below the crushing zone.

The crushing zone is that size range between the crusher setting and 1.7 times the crusher setting. The crusher setting is the decision variable for the unit and 1.7 is a constant specified by the user in the equipment type specification.

All material larger than the crusher zone is broken into material which is no larger than the upper bound of that zone. The breakage distributions used are specific to the crusher type. Table I-4-9.1 shows these distributions along with the values of the general one proposed by Broadbent and Calcott(10). The general curve is computed from the equation given earler. The source of the crusher specific curves is unknown.

The material in the crushing zone is broken in accordance with the general breakage distribution. The additional assumption is made that some particles may slip through unbroken in accordance with the screening equation. The screening constant is 8 for primary crushers and 2 for secondary crushers. There is also a selection for breakage factor of .85. The smallest material is as above without the slippage assumption.

TABLE I-4-9.1. CRUSHER BREAKAGE DISTRIBUTIONS

Size ratio	General distribution	Multiple roll crusher	Gyratory /jaw crusher	Single roll crusher	Primary cage mill crusher
1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
.8308	.8927	.9500	.9500	.9600	.8400
.5882	.7035	.8500	.8500	.7900	.5000
.4176	.5400	.6500	.7000	.4500	.3200
.2065	.2952	.3500	.3500	.2000	.1500
.1041	.1564	.2200	.2000	.1000	.0520
.0522	.0805	.1400	.1900	.0500	.0190
.0368	.0572	.1100	.1700	.0300	.0110
.026	.0406	.0900	.1200	.0200	.0066
.0131	.0206	.0300	.0800	.0000	.0020
.0000	.0000	.0000	.0000	.0000	.0000

4.10 Dewatering

The mathematics of dewatering is concerned with the splitting of the input flow into two output flows, one of which consists mainly of water. As a secondary effect breakage occurs during the operation of the dewatering device. Thus the unit operation of dewatering can be treated simply as a splitting operation combined with prebreakage. These operations are described in 4.2 and 4.7.4.

5.0 THE COMPUTATION OF COST

This chapter describes the cost computation component of program CPSM4. In essence the purpose of this component is to model the economics of the coal preparation process. In particular, this component is intended to estimate that per unit price at which the material in the salable output flows must be sold so as to meet the costs required to produce those flows. Those costs, of course, include a reasonable, user specified, rate of return on the investment made to establish the configuration. The cost component is implemented within CPSM4 so that the combined capabilities of the process simulation component and the cost component can be used to perform detailed performance-cost trade-off studies for the coal preparation process.

There were several major problems encountered during the attempt to interface a cost computation procedure with the process simulation. Most importantly, as was discussed in part I-2.0, the process simulation is explicitly assumed to be steady-state. The behavior of the system being simulated is assumed not to vary as a function of time. This assumption, though simplifying, appears to cause no major inaccuracies in the results of the process simulation. Unfortunately, any reasonably sophisticated approach to the estimation of the costs associated with a project must deal with the notion of cash flows. These cash flows vary dramatically through the life of a project--construction, operation, and shutdown; therefore, they must be characterized as time series. The steady-state assumption cannot be maintained in the cost computation component.

The second problem encountered has to do with relating the cost computations to the units and flows in the configuration simulated by the process component. Obviously, many of the costs such as price of raw coal, price of equipment, and operating labor, relate directly to the units and flows; however, many other costs, such as price of land, transportation costs, and administration, do not relate directly to the elements in the configuration. Even those costs which do bear on the units and flows in apparently straightforward ways, require that the configuration be sized before they can be calculated. The reader is reminded that the process simulation estimates all flowrates simply as a percent of feed or as tons per hour. There is no information as to how much material is being processed over the life of the configuration. This information is critical if the configuration is to be costed.

Expanding the above point slightly, once a given configuration has been simulated, there are potentially many different cost scenarios which might be calculated. The following represent some of the different types of questions which the user might wish to ask:

(1) How does the selling price vary as the overall output capacity of the configuration varies?
(2) How does the selling price vary as the purchase price of various elements needed varies?
(3) How does the selling price vary as a function of the desired level of rate of return on investment?

The number of combinations of questions which might be asked is extremely large. If the entire process simulation had to be executed on the computer separately for each costing scenario, then the computer resources required by CPSM4 might well become prohibitive.

The basic conclusion drawn as a result of the above types of issues was that the cost computation component should not be structured as an integral part of the process simulation component; rather it should be implemented as a post-processing step. Physically, at that point in time in the computer program, the following information is available:

(1) The equipment inventory
(2) The description of the configuration
(3) The summary data for flowstreams.

The most important of these is the summary data for flowstreams which includes the following composite information for each flowstream in the configuration:

(1) Flow rate as a percent of total feed
(2) Percent by weight of flow which is ash
(3) Percent by weight of flow which is pyritic sulfur

(4) Percent by weight of flow which is total sulfur
(5) Average Btu per pound.

The information which is no longer available to the program once the process simulation has completed its work includes the following:

(1) The detailed size and specific gravity analyses of the flowstreams, and
(2) The detailed performance characteristics of the units.

The fundamental assumption, then, made in the implementation of the cost component is that the costs associated with the establishment and operation of a coal preparation configuration do not vary as a function of the detailed characteristics of either the flowstreams or unit performances. This assumption is clearly a simplifying one. No attempt will be made in this presentation to justify this assumption. It is taken as given.

As will be described in more detail later, a major benefit is derived from implementing the cost computation component in program CPSM4 as a post-processing step. The cost component may be used independently of the process simulation. If the user merely wishes to estimate the costs associated with an arbitrary project, he can use CPSM4 to perform the calculations. It must be emphasized, however, that the complete power of the cost component is realized only via the use of it in conjunction with the process simulation component.

In addition to the information needed to execute the process simulation, if the user is executing that component, he must provide the cost component with an inventory of the basic cost elements to be considered. The values of these elements may be

(1) Constant
(2) Functionally related to the summary data for some flowstream
(3) Functionally related to other cost elements or sums of cost elements.

The manner in which these are defined is described later in this volume.

Based on the configuration data and on the cost element inventory, the user may run many different costing scenarios as described briefly earlier in this part. The basic interface between the disaggregated information described above and the actual procedures which calculate the capital costs and which take into account the desired rate of return on investment is the project cash flow description. This cash flow description is a time series specification of the aggregated annual cash flows required to construct the configuration and to operate it over its entire life. The content and use of this project cash flow description is discussed in the next part.

5.0.1 An Example Project to be Costed

The following discussion will be persented in terms of the Cost Component Example presented in part 2.2. The actual results for this example are presented in Appendix B.

5.1 Measuring Profitability

As was stated in the introduction to this chapter, the goal of the cost computation algorithm in program CPSM4 is to estimate that per unit selling price of the output flows of coal which will exactly recoup the costs incurred in producing those flows and which will guarantee a certain level of profit, or rate of return on investment, for the investment capital. To take the desired level of profit into account is by far the most difficult part of the computation. The method used in program CPSM4 for measuring profitability is the discounted cash flow method.

5.1.1 The Project Cash Flow Description

To measure the profitability of some project requires a description of all capital and operating expenditures and of all earnings on an annual basis over some period of time. The normal period of time used is the entire life of the project from the beginning of construction through the end of operation when the project is closed down and the working capital is withdrawn. Though nothing in the following discussion requires that the user measure profitability over the entire life of the coal preparation plant, this is the normal convention and to simplify the discussion it will be assumed.

The set of values which describes the project expenditures and income will be referred to as the "project cash flow description", or simply CFD. Each of the measures of profitability is predicated primarily on the project CFD along with various other overall parameters specifying such things as the desired level of profitability, the income tax rate, etc. The first step, then, in describing the measurements of profitability consists of explaining the content of the project CFD. To serve as an example for this explanation the User Handbook Cost Example, page 10 of Appendix B, (p. 233) shows a CFD. The source of this table is Holt(5) which was presented in part 2.2.

As can be seen on this page, the first column in the project CFD is the year time value. The normal convention is that the plant goes into production at the beginning of year 1, though it need not be in full production at that time. The last year of construction and start-up occurs during year 0 and so back to year -1, -2, to the start of production. The example shown has a construction period of 1 year and an operational life of 10 years.

The second column in the project CFD is the annual production. The purpose of this column is to serve as a basis for the computation of gross annual income. Remember that the purpose of the cost computation is to measure the selling price. This price multiplied times annual production would give the gross annual income. The entries in this column will always be zero during the construction and start-up periods and will typically be constant during the operational period except for the first and last years. This level of production value would typically come from the flowstream summary report data of the process simulation component of the program. The user would specify the amount of feed and using the flowrate (percent of feed) values, CPSM4 would compute the amount of output. In this case the program is told that the total annual feed to the plant is 1.56 million tons of coal. Thus the annual production of clean coal is as shown below:

$$1.56 \times 10^6/600 \times 363.9 = 946{,}140 \text{ tons per year.}$$

In this case 600 is the hourly feed to the plant in tons, while 363.9 is the hourly clean output flow, in tons, from the plant (see flowstream number 26 on page 6 of the User Handbook Cost Example, Appendix B [p. 229]).

The third column in the cash flow description is the amount of capital investment which may be depreciated. Included in this column is the cost of equipment, the cost of buildings, and so on. If some component of the above has a salvage value, then only the difference between the total cost and the salvage value would be entered in this column. In the case of the example, the figure of 3.94 million dollars comes directly from the total capital requirement figure on page 8 of Appendix B (p. 231). There the figure was computed by summing the various components listed in the cost element description.

The fourth column in the CFD is the nondepreciable capital investment column. This column contains the cost of land, the amount of working capital needed, and the salvage values of depreciable capital costs. Note that the negative of the total nondepreciable capital investment should be entered for the last year of operation. This entry reflects the withdrawal of working capital, land, and salvage by the investors at the end of the project. In the present example, Holt(5) gave no information as to the levels of nondepreciable capital needed; therefore, they were assumed to be zero.

The fifth column in the project cash flow description contains the annual operating costs. It includes such things as the cost of raw materials and utilities, labor and maintenance costs, administration and overhead costs, etc. Overall, it includes all costs incurred to produce and sell the product, other than capital costs. It may include various negative elements reflecting byproduct credits. It does not include depreciation, other income tax credits, or income tax payments. In the case of the example, the annual figure of 2.48 million dollars comes directly from page 9 of Appendix B (p. 232).

The sixth column in the project cash flow description is depreciation. Though the values for depreciation may be explicitly entered into the CFD by the user via the cost elements, the depreciation is normally calculated by the program from the value of the depreciable capital investment. To perform this calculation, CPSM4 assumes straight-line depreciation over the life of the project.

The seventh column in the project cash flow description is other tax allowances. In the present example, these are assumed to be zero.

5.2 The Discounted Cash Flow Analysis

Once the project cash flow description has been completed, the calculation of the discounted cash flow analysis, or DCF, can be made. The only additional information which must be supplied by the user is the desired rate of return on investment and the tax rate to be applied to earnings. The purpose of the DCF analysis is to estimate that per unit price at which the material in the salable output flows must be sold so as to meet the costs required to produce those flows, including a desired rate of return on investment.

The key notion about which the DCF analysis revolves is the discount factor (also known as present worth factor) shown in column 6 on page 11 of the User Handbook Cost Example, Appendix B (p. 234). The present value, P, of a future sum of money, F, is given by

$$P = F \times d_t$$

where $d_t = 1/(1+i)^t$ is the discount factor in the t-th year for rate i. By multiplying annual cash flows times their corresponding discount factors, one obtains the annual discounted cash flows. By definition the net present value of a project is the sum of its discounted cash flows. The true rate of return of a project is that value of i in the calculation of the discount factor which makes the net present value over the entire life of the project equal to zero. The purpose of the program then is to calculate that selling price which makes the user-specified desired rate of return the true rate of return for the project.

5.2.1 Basic Identities Used

This part defines the basic identities and definitions from which the DCF procedure is derived. To simplify the following discussion, the following notation will be used to represent the values in the CFD:

Y_t - the value of the t-th year

P_t - the annual amount of production in the t-th year

CD_t - the annual amount of depreciable capital investment in the t-th year

CN_t - the annual amount of nondepreciable capital investment in the t-th year

O_t - the annual amount of operating expenses in the t-th year

D_t - the annual amount of depreciation in the t-th year

A_t - the annual amount of other tax allowances in the t-th year.

The symbol, r, is used to denote the tax rate and the symbol, S, is used to denote the per unit selling price for production. Note that these are assumed to be a constant.

Taxable income, TI_t, is defined as follows:

$$TI_t = S \times P_t - O_t - D_t - A_t \quad .$$

Thus, it equals gross annual sales less operating expenses, depreciation, and allowances. Note that it may be negative. This will often be true for projects with heavy start-up expenses.

Taxes, TX_t, are defined as follows:

$$TX_t = \begin{cases} TI_t \times r & \text{if } TI_t > 0 \\ 0 & \text{if } TI_t \leq 0 \quad . \end{cases}$$

Note that in this formulation no tax credits are estimated. This might well be a valuable future enhancement.

Annual cash income after taxes, CI_t, is computed from

$$CI_t = S \times P_t - O_t - TX_t \quad .$$

It equals gross sales less operating expenses and taxes.

Annual cash flow, CF_t, is defined as follows:

$$CF_t = CI_t - CD_t - CN_t \quad .$$

It is annual cash income minus annual capital investment. Note that values of CF_t may be positive or negative.

The annual discounted cash flow, DF_t, is then

$$DF_t = CF_t \times d_t \quad .$$

Here d_t is the annual discount factor presented earlier. Finally, NPV is the net present value of the project; thus,

$$NPV = \sum_{t=1} DF_t$$

By definition, the project achieves the desired true rate of return when the value of S is established so as to make NPV equal to zero.

On page 11 of Appendix B (p. 234), column one is t, two is TI_t, three is TX_t, four is CI_t, five is CF_t, six is d_t, and seven is DF_t. Note that the sum of column seven is zero.

5.2.2 The Actual Procedure

The actual procedure for calculating S from the definitions in the previous part would be straightforward it it were not for the calculation of TX_t which is contingent on the value of S. Since this contingency is present, a convergence approach must be used. Fortunately, the convergence is well-behaved and the solution can be derived quickly.

The first step in the procedure is based on the assumption that negative taxes are possible in the form of a net increase to cash income in a given year. This assumption is obviously false; however, it gives a good first guess, which is often the final result. The implementation of this assumption is to define taxes simply as follows:

$$TX_t = TI_t \times r \quad .$$

Taxes equal taxable income times the tax rate for all incomes--even negative ones.

Using this assumption, it is possible to solve for S.

$$NPV = \sum_t DF_t = 0 \qquad \text{(by definition)}$$

$$\sum_t (CI_t - CD_t - CN_t) \times d_t \qquad \text{(by substitution)}$$

$$\sum_t (S \times P_t - O_t - TI_t \times r - CD_t - CN_t) \times d_t = 0 \quad \text{(by substitution)}$$

$$\sum_t (S \times P_t - S \times P_t \times r) \times d_t = \sum_t (O_t - O_t \times r - D_t \times r - A_t \times r + CD_t + CN_t) \times d_t$$

$$S = \left(\sum_t [O_t \times (1-r) - D_t \times r - A_t \times r + CD_t + CN_t] \times d_t\right) / \left([1-r] \times \sum_t P_t \times d_t\right)$$

Now, in the case where TI_t is greater than zero for all t, this estimate of S is the correct one as the assumption

$$TX_t = TI_t \times r$$

is true for all t. The problem comes in those cases where TI_t is negative. In these cases, the resultant NPV calculated on the first estimate of S will be negative. Assume its value is NPV'. The procedure computes this value and a new value of S as follows:

$$S_1 = S_o - NPV'/\left((1-r) \times \sum_t P_t d_t\right).$$

This continues until the value of NPV' converges with zero.

6.0 PREPARING THE INPUT

This chapter provides a detailed description of how to prepare and code information for program CPSM4. The input data deck to the program consists of six segments in this order:

(1) Run control
(2) Equipment inventory
(3) Configuration
(4) Feed description
(5) Configuration and feed selection
(6) Cost calculation description.

Each of these segments is discussed separately, in the above order except that the run control segment is presented last.

The discussion of each begins with a formal description of the coding procedures to be used followed by an informal discussion of those procedures. Also included is a listing of and general comments about the actual input used to generate the user handbook printouts. In addition to the parts of this chapter describing the preparation of the input, other parts are included which contain information of a more general nature.

All input is described as though it were being physically read into the program in punch card form. This is done for convenience of reference only. In fact, the input decks might well be maintained and input from some general text editor available on the various computers. The only real restriction is that the input be in coded card-image form.

The data for segments 2, 3, and 4 may be in coded card-image form, or it may be read from feed and configuration data bases in which case these segments are missing from the input data deck. If the data for those segments is present in the data deck then two data bases are created storing that input information. If those data bases are permanently saved at the end of the run, then future runs may be made using the information directly from the data bases. This greatly reduces the size of the input data deck needed.

The two data bases that are created are

(i) the configuration data base, stored on file unit 3, and
(ii) the feed data base, stored on file unit 4.

The configuration data base contains the equipment inventory together with up to thirty configuration specifications that employ that equipment inventory. The feed data base consists of up to thirty feed descriptions, all of which are assumed to have the same numbers of size fractions and specific gravity fractions, and the same characteristics. Each configuration and each feed is identified by a unique key supplied by the user. The keys are used to identify and select the particular configuration and feeds that are to be used in a given run.

6.1 General Coding Conventions

All of the information entered into the program via the input data deck is organized on cards in fixed-field form. There are various conventions associated with fixed-field input, which derive from the interaction of various FORTRAN FORMAT rules and from the particular manner in which these are implemented in this program.

Most fundamental is the notion of the character set. All information entered into the program is written and then punched onto cards. The particular characters which may be used in writing this input are limited to those which can be recognized or accepted by the program. The entire group of these is the character set accepted. The character set accepted by this program consists of the following 47 characters:

(1) The numeric characters (0-9)
(2) The alphabetic characters (A-Z)
(3) Special characters (+ - * / = ( ) $. , b).

Note that the symbol b is used to indicate a blank. All alphabetic characters are upper case. This character set, though admittedly limited, is more than sufficient to meet the needs of this program.

At the next conceptual level above that of the character set is the notion of the field. A field is defined as a set of contiguous character positions on an input record. The character positions on the input records, which are typically referred to as columns, are numbered consecutively from 1 to 80 from left to right. Within the coding instructions fields will typically be defined in terms of their inclusive beginning column number and ending column number. The basic characteristics of a field is its width. The width of a field equals its ending column number minus its beginning column number plus 1. Thus, an eight character field beginning in column 10 would end in column 17; or conversely, a field beginning in column 10 and ending in column 17 would be an eight character field.

Information being entered into fields will be referred to as being right-justified or left-justified. Information is right-justified in a field if the last nonblank character appears in the ending column defined for that field; and information is left-justified if the first nonblank character appears in the beginning column of the field. These notions of right and left justification are especially important as they relate to the coding of numeric information.

Since most of the information being entered into the program is numeric and is being processed under the control of FORTRAN FORMAT specifications, a brief description of the general conventions associated with the entry of numeric data for processing of the above type is needed. The basic problem is that all blanks within a fixed numeric field are interpreted as though they were zero. This is a universal convention for all FORTRAN progams; therefore, it is followed in this program. As will be discussed below, this convention is a major source of error in the preparation of input to programs.

As an example, the entries -- bb123, b123b, 123bb -- when entered into a five character field would be interpreted as though they had been written as 00123, 01230, and 12300, respectively. They would, therefore, be assigned the values of 123, 1230, and 12,300. The point is that the user must be very careful to enter this type of integer data right-justified in its field. If he does not, it will be interpreted in the wrong way. Great care must be taken, since justification errors are very difficult to see when an input listing is being proofread.

The case for real data, which may include a decimal point, is slightly less dangerous if the decimal point is always included. Using the above example, the entries -- bb123., b123.b, 123.bb, when entered in a six character field would be interpreted as though they had been written as 00123., 0123.0, and 123.00, respectively. These would all be assigned the same value.

In conclusion, all fields to contain numeric information will be said to be integer or real in the following coding instructions. Information being placed into integer fields may not be shown with a decimal point and must be right-justified. Information being placed in real fields should always be shown with an explicit decimal point and may be entered anywhere in its field.

The other type of information entered into the program is nonnumeric, descriptive information. Fields containing this type of information will be referred to as descriptive fields. Generally, information entered into descriptive fields should be left-justified; however, the ramifications of not following this convention are minor. It should be pointed out that any character not included in the character set when used in a descriptive field will be replaced by a blank in the program.

6.2 The Equipment Inventory

From a logical standpoint, the first input which must be prepared is the equipment inventory. This is by far the most complex input, but once prepared, it is the least likely to change. The equipment inventory contains a general mathematical description of each type of equipment of possible interest in the simulation. This description is linked to the unit operations described in the previous chapter. It should be pointed out that in the original version of the program, the equipment inventory was hardwired into the program. The advantage of this approach was that the user did not have to concern himself with the details of the equipment specification.

From the standpoint of the current version of the program, the disadvantage of this approach is that the user has no control over the equipment specification and, thus, cannot tune the program to particular applications which do not follow the generalized behavior assigned to the equipment types by Gottfried, Jacobsen, and Vaillant(1). The point is that there are two very different, yet by no means incompatible, situations in which a program like CPSM4 might be used.

In one situation the user is interested in simulating "the performance of...configurations representative of actual preparation plants" (Gottfried, Jacobsen, and Vaillant(1)). He is not simulating an actual plant, but rather is examining a representative picture of some configuration as it might impact on some type of coal. Such analysis is important and valuable for the various design tasks which might precede the actual construction of a plant or, perhaps more importantly, which might precede the decision to even build a plant.

At the other extreme the user is not interested in a representative configuration, rather he is interested in a very particular plant which might already be in operation. If he could tune the equipment inventory description to the point that the simulation results agreed closely with actual experience, then he could effectively use the program to evaluate changes in the feed characteristics of the coal and/or changes in the plant configuration or equipment set points. This level of use is precluded by the approach taken in the original version.

Both levels of use, and any level in between, are possible in the current version. The equipment inventory prepared for the user handbook example, which is completely described in the following section, contains all of the equipment types included in the original version. It is just these types for which generalized descriptions have been prepared. Those users who only wish to use the program in its representative mode may simply take that input as given and need not study the following discussion which relates to specifying the equipment inventory. Figure I-6-2.1 shows the equipment types for which general characterizations have been prepared.

Code	Equipment type	Unit operation
41	stream blender	blending
51	stream splitter	splitting
52	centrifuge	splitting
1	concentrating table	washing
2	dense-medium vessel	washing
3	dense-medium cyclone	washing
4	hydrocyclone	washing
5	single-stage Baum jig	washing
6	two-stage Baum jig	two-stage washing
7	froth flotation cell	froth flotation
11	rotary breaker	rotary breaking
12	primary multiple roll crusher	crushing
13	primary gyratory/jaw crusher	crushing
14	primary single roll crusher	crushing
15	primary cage mill crusher	crushing
16	secondary multiple roll crusher	crushing
17	secondary gyratory/jaw crusher	crushing
18	secondary single roll crusher	crushing
19	secondary cage mill crusher	crushing
21	dry upper screen	screening
22	dry lower screen	screening
23	wet upper screen	screening
24	wet lower screen	screening

FIGURE I-6-2.1. THE GENERALIZED EQUIPMENT INVENTORY

6.3 Coding the Equipment Inventory

Figure I-6-3.1 contains the field descriptions to be used in coding the equipment inventory segment of the input deck to the program, while Figure I-6-3.2 contains a listing of the actual equipment inventory segment used for the user handbook example. This equipment inventory includes not only the actual equipment types used in the example plant configuration, but also all other types for which generalized data is available. On Figure I-6-3.1 the fields are organized into eight general card types as shown. This part discusses these card types, their organization into the equipment inventory, and their content in detail.

Since the primary purpose of the equipment inventory segment of the input deck is to give the user selective access to and control of the unit operations contained within the program, this discussion will rely heavily on the material presented in the previous chapter on the mathematics of the unit operations. Unfortunately, some references to the material in the following chapter on interpreting the output of the program must also be made. It is hoped that these do not cause too much difficulty.

6.3.1 Equipment Inventory Count Card

The first card in the equipment inventory segment of the input deck to program CPSM4 is the equipment inventory count card. This card contains a single integer field in columns 1 through 5. This field specifies the number of equipment types to be included in the inventory. In the case of the user handbook example, this field contains the entry 23 which represents the total number of equipment types for which generalized data have been prepared. The equipment inventory count card for the user handbook example is shown as the first card in Figure I-6-3.2. Following the equipment inventory count card in the inventory segment of the input deck, there are as many equipment type subsegments as specified in the inventory count field.

I. Equipment Inventory Count Card

Field	Type	Description
1-5	integer	number of equipment types

II. Equipment Type Definition Card

Field	Type	Description
1-5	integer	identifier for equipment type
6-10	integer	unit operation code for equipment type
		code unit operation
		1 blending
		2 splitting
		3 screening
		4 washing
		5 two-stage washing
		6 froth flotation
		7 rotary breaking
		8 crushing
11-15	integer	prebreakage control flag for equipment type
41-80	descriptive description of equipment type	

III. Washing Special Information Card

Field	Type	Description
1-8	real	offset for denominator in imperfection calculation

IV. Rotary Breaking Special Information Card

Field	Type	Description
1-8	real	number of falls calculation constant
9-16	real	hole size threshold value
17-24	real	screening constant if hole size below threshold
25-32	real	screening constant if hole size not below threshold
33-40	real	height selection factor for breakage adjustment

FIGURE I-6-3.1, FIELD DESCRIPTIONS FOR CODING EQUIPMENT INVENTORY

V. Crushing Special Information Card

Field	Type	Description
1-8	real	selection constant
9-16	real	crushing range calculation constant
17-24	real	screening constant

VI. Distribution Definition Card

Field	Type	Description
1-5	integer	curve set type code code meaning 1 1-dimensional vector 2 univariate distribution 3 size classification curves 4 c-generalized distribution curve 5 nongeneralized set of distribution curves
6-10	integer	number of points per vector or distribution
11-15	integer	number of size fractions or univariate distributions or size distributions

VII. Miscellaneous Real Values Specification Card

Field	Type	Description
1-8	real	these fields are used for the entry of miscellaneous real values associated with the specifications of the equipment distributions
9-16		
17-24		
25-32		
33-40		
41-48		
49-56		
57-64		
65-72		
73-80		

VIII. Miscellaneous Integer Value Specification Card

Field	Type	Description
1-5	integer	This field is used for the entry of miscellaneous integer values associated with prebreakage.

FIGURE I-6-3.1. (Continued)

IX. Number of Curves per size Fraction Card

Field	Type	Description
1-5		
6-10		
11-15		these fields specify the number of
16-20	integer	actual distribution curves to be
.		specified per size fraction
.		
.		
.		
76-80		

FIGURE I-6-3.1. (Continued)

```
   23                                                        STREAM BLENDER
   41      1                                                 STREAM SPLITTER
   51      2                                                 CENTRIFUGE
   52      2       1
    6
    1
20.0      0.25      0.125     0.046     0.0116    0.0058    0.0029
0.7264    0.5764    0.5178    0.1921    0.0034    0.2742
                                                             DRY UPPER SCREEN
   21      3
    2      9       1
18.0      6.0       1.5       0.375     0.25      0.093     0.0232    0.0164    0.0116
60.0      20.0      8.0       8.0       5.0       3.0       0.7       0.6       0.5
                                                             DRY LOWER SCREEN
   22      3
    2      9       1
18.0      6.0       1.5       0.375     0.25      0.093     0.0232    0.0164    0.0116
60.0      20.0      8.0       6.0       4.0       2.0       0.7       0.6       0.5
                                                             WET UPPER SCREEN
   23      3
    2      9       1
18.0      6.0       1.5       0.375     0.25      0.093     0.0232    0.0164    0.0116
60.0      20.0      9.0       8.6       5.5       3.5       0.8       0.7       0.55
                                                             WET LOWER SCREEN
   24      3
    2      9       1
18.0      6.0       1.5       0.375     0.25      0.093     0.0232    0.0164    0.0116
60.0      20.0      9.0       6.6       4.5       2.3       0.8       0.7       0.55
                                                             CONCENTRATING TABLE
    1      4
1.0
    4     20       7
100.0000   .2500     .0930     .0460     .0232     .0116     .0058    0.0000
   .8181   .8694     .8793     .8892     .9030     .9129     .9218     .9267     .9416     .9584
   .9880  1.0186    1.0532    1.0581    1.0670    1.0769    1.0868    1.0977    1.2844    1.4820
  1.0000   .9930     .9870     .9780     .9600     .9400     .9200     .9000     .8000     .6900
   .5000   .3000     .0800     .0600     .0430     .0330     .0260     .0230     .0110    0.0000
   .8290   .8509     .8648     .8747     .8847     .8966     .9045     .9314     .9433     .9642
   .9940  1.0288    1.0387    1.0626    1.0835    1.1093    1.1332    1.1610    1.1928    1.5467
  1.0000   .9970     .9930     .9870     .9770     .9630     .9480     .9000     .8000     .6750
   .5000   .3000     .2400     .1800     .0990     .0600     .0400     .0260     .0180    0.0000
   .7646   .8279     .8425     .8620     .8766     .8961     .9058     .9497     .9740    1.0227
  1.0519  1.0665    1.0909    1.1201    1.1688    1.2272    1.6558    1.7532    1.8506    1.9480
  1.0000   .9970     .9940     .9810     .9600     .9200     .8800     .6350     .5000     .2790
   .1480   .1000     .0680     .0460     .0250     .0180    0.0000    0.0000    0.0000    0.0000
   .7362   .7954     .8051     .8245     .8391     .8488     .8633     .8827     .9021     .9700
  1.0379  1.0573    1.0864    1.1252    1.1689    1.2853    1.4308    1.6189    1.7460    1.9400
  1.0000   .9930     .9910     .9830     .9720     .9620     .9390     .8870     .8170     .5060
   .2460   .1950     .1450     .1030     .0730     .0400     .0150    0.0000    0.0000    0.0000
   .7515   .7813     .8018     .8306     .8635     .8861     .9252    1.0280    1.1514    1.1925
  1.2336  1.2953    1.3364    1.3981    1.6448    1.8504    2.0560    2.1074    2.1588    2.2102
  1.0000   .9940     .9870     .9680     .9320     .9000     .8000     .5000     .2000     .1350
   .0990   .0660     .0520     .0400     .0260     .0210     .0200     .0200     .0200     .0200
   .7479   .8122     .8798     .9250     .9723    1.0017    1.0332    1.1280    1.1573    1.1731
  1.2171  1.2634    1.3762    1.3987    1.4326    1.4890    1.5566    2.2560    2.3124    2.3688
  1.0000   .9770     .9410     .9080     .8620     .8230     .7580     .5000     .4200     .3750
   .3000   .2370     .1000     .0800     .0600     .0400     .0300     .0200     .0200     .0200
   .7345   .7757     .8242     .8775     .9211     .9696    1.0132    1.0326    1.0908    1.2120
  1.2847  1.3623    1.4544    1.5998    1.6968    1.9392    2.4240    2.4846    2.5452    2.6058
  1.0000   .9980     .9920     .9810     .9630     .9470     .9190     .9000     .8000     .5000
   .4000   .3390     .2920     .2430     .2190     .1770     .1200     .1200     .1200     .1200
```

FIGURE I-6-3.2. LISTING OF EQUIPMENT INVENTORY SEGMENT FOR USER HANDBOOK EXAMPLE

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```
    2     4                                          DENSE-MEDIUM VESSEL
0.0
    4    20      5
100.0000   4.0000   2.0000   1.0000    .5000   0.0000
    .9399    .9457    .9487    .9496    .9612    .9690    .9787    .9903    .9923    .9932
    .9961   1.0010   1.0078   1.0175   1.0271   1.0368   1.0465   1.0562   1.0659   1.0756
   1.0000    .9970    .9930    .9800    .7000    .5000    .2600    .0120    .0060    .0030
    .0010   0.0000   0.0000   0.0000   0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
    .9104    .9221    .9320    .9437    .9566    .9584    .9653    .9810    .9859    .9957
   1.0045   1.0075   1.0153   1.0242   1.0359   1.0369   1.0379   1.0389   1.0399   1.0408
   1.0000    .9890    .9770    .9590    .9450    .9190    .8000    .5000    .4000    .2100
    .0400    .0270    .0130    .0050   0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
    .8719    .8937    .9205    .9394    .9553    .9682    .9731    .9811    .9930   1.0059
   1.0208   1.0258   1.0357   1.0476   1.0575   1.0774   1.0784   1.0794   1.0804   1.0814
   1.0000    .9930    .9780    .9620    .9400    .9060    .8440    .7000    .5000    .2880
    .0680    .0480    .0300    .0150    .0090   0.0000   0.0000   0.0000   0.0000   0.0000
    .7828    .9322    .9474    .9595    .9666    .9757    .9908   1.0100   1.0353   1.0555
   1.0656   1.0807   1.0938   1.1161   1.1272   1.1282   1.1292   1.1302   1.1312   1.1322
   1.0000    .9930    .9870    .9760    .9540    .8600    .7000    .5000    .2470    .0460
    .0250    .0130    .0070    .0010   0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
    .8434    .8629    .8887    .9207    .9485    .9712    .9867    .9898   1.0104   1.0310
   1.0527   1.0640   1.0722   1.0826   1.1083   1.1393   1.1702   1.2114   1.2372   1.2753
   1.0000    .9970    .9910    .9750    .9560    .9310    .8990    .8800    .6900    .5000
    .3000    .2680    .1600    .1200    .0710    .0400    .0200    .0060    .0020   0.0000
    3     4                                          DENSE-MEDIUM CYCLONE
0.0
    4    20      6
100.0000    .5000    .3750    .2500    .0930    .0460   0.0000
    .9413    .9502    .9602    .9652    .9581    .9691    .9950   1.0179   1.0199   1.0229
   1.0278   1.0358   1.0448   1.0547   1.0647   1.0726   1.0736   1.0746   1.0756   1.0766
   1.0000    .9970    .9900    .9830    .9780    .9700    .5000    .0660    .0540    .0400
    .0300    .0200    .0120    .0060    .0020   0.0000   0.0000   0.0000   0.0000   0.0000
    .9069    .9148    .9297    .9396    .9475    .9544    .9574    .9742    .9890   1.0088
   1.0216   1.0236   1.0286   1.0385   1.0513   1.0632   1.0642   1.0652   1.0661   1.0671
   1.0000    .9970    .9910    .9850    .9780    .9700    .9520    .7400    .5000    .2200
    .0400    .0290    .0190    .0080    .0020   0.0000   0.0000   0.0000   0.0000   0.0000
    .8939    .9315    .9415    .9474    .9543    .9563    .9712    .9910   1.0059   1.0217
   1.0237   1.0277   1.0386   1.0524   1.0653   1.0812   1.0822   1.0832   1.0842   1.0851
   1.0000    .9920    .9870    .9820    .9730    .9680    .7600    .5000    .2800    .0560
    .0440    .0340    .0200    .0100    .0050   0.0000   0.0000   0.0000   0.0000   0.0000
    .8761    .8891    .8991    .9141    .9441    .9590    .9670    .9790    .9990   1.0140
   1.0300   1.0390   1.0539   1.0739   1.0989   1.1289   1.1389   1.1578   1.1588   1.1598
   1.0000    .9990    .9980    .9960    .9880    .9790    .9650    .8000    .5000    .3200
    .1200    .0880    .0620    .0410    .0240    .0100    .0060   0.0000   0.0000   0.0000
    .8458    .8763    .8967    .9181    .9426    .9599    .9731    .9782    .9823    .9986
   1.0190   1.0496   1.0567   1.0771   1.0954   1.1229   1.1617   1.1973   1.2452   1.3247
   1.0000    .9970    .9940    .9860    .9690    .9510    .9280    .9140    .8960    .7200
    .5000    .1940    .1560    .1000    .0730    .0500    .0290    .0160    .0060   0.0000
    .8076    .8336    .8701    .8857    .9378    .9639    .9795    .9899    .9951   1.0160
   1.0420   1.0785   1.0889   1.0941   1.1045   1.1358   1.1723   1.3546   1.5703   1.5713
   1.0000    .9960    .9880    .9830    .9580    .9370    .9170    .8970    .8800    .7100
    .5000    .2060    .1300    .1100    .0890    .0550    .0360    .0140   0.0000   0.0000
    4     4                                          HYDROCYCLONE
1.0
    4    20      7
100.0000    .1850    .0930    .0460    .0232    .0116    .0058   0.0000
```

FIGURE I-6-3.2. (Continued)

```
   .5670    .5994    .6383    .6699    .6958    .7128    .7371    .7476    .7630    .8100
   .8262    .8570    .9185    .9437    .9769   1.0368   1.1057   1.1988   1.2799   1.3770
  1.0000    .9910    .9650    .9300    .8900    .8570    .7930    .7580    .7020    .5000
   .4400    .3390    .1530    .1090    .0740    .0340    .0170    .0070    .0030   0.0000
   .5052    .5894    .6652    .7241    .7578    .7999    .8420    .8715    .9052    .9262
   .9649   1.0045   1.0390   1.0794   1.1687   1.3135   1.3977   1.5139   1.5148   1.5156
  1.0000    .9620    .9080    .8350    .7680    .6460    .5060    .4000    .2980    .2470
   .1750    .1150    .0700    .0480    .0290    .0120    .0040   0.0000   0.0000   0.0000
   .3875    .4520    .4951    .5467    .5994    .7103    .7964    .8352    .8610    .9041
   .9213    .9514   1.0117   1.0616   1.1064   1.1451   1.2269   1.3561   1.5068   1.6359
  1.0000    .9910    .9650    .9390    .8050    .7910    .6780    .5950    .5000    .3320
   .2770    .2210    .1450    .0950    .0670    .0530    .0350    .0170    .0030   0.0000
   .2868    .3633    .4589    .5507    .5908    .6682    .7648    .8528    .8986    .9560
  1.0267   1.0516   1.1013   1.1453   1.2237   1.2638   1.3002   1.7151   2.2179   2.2275
  1.0000    .9890    .9680    .9410    .9250    .8810    .8060    .7130    .6400    .5000
   .3260    .2790    .2000    .1400    .0630    .0410    .0300    .0110   0.0000   0.0000
   .3491    .4565    .5553    .6659    .8055    .8485    .9022    .9419    .9612   1.0740
  1.3210   1.3339   1.3694   1.4016   1.4306   1.4499   1.5057   1.6916   2.0406   2.0513
  1.0000    .9950    .9830    .9540    .8860    .8580    .8140    .7690    .7350    .5000
   .0940    .0780    .0490    .0330    .0240    .0200    .0170    .0120   0.0000   0.0000
   .5635    .6127    .6738    .8441    .9538    .9844   1.0096   1.0479   1.0791   1.1990
  1.2482   1.2913   1.3549   1.5143   1.5587   1.6103   1.6546   1.8117   1.9184   2.0383
  1.0000    .9990    .9940    .9540    .9100    .8910    .8730    .8380    .7930    .5000
   .3810    .3130    .2460    .1210    .0930    .0690    .0530    .0210    .0090   0.0000
   .6810    .8513   1.1577   1.1781   1.1918   1.2054   1.3628   1.3892   1.4097   1.4369
  1.4710   1.4982   1.5731   1.6072   1.6276   1.6548   1.7025   1.7910   1.8728   1.8741
  1.0000    .9850    .9000    .8760    .8630    .8440    .5000    .4400    .4000    .3610
   .3210    .2950    .2300    .2050    .1930    .1790    .1570    .1230    .1000    .1000
    5    4                                       SINGLE-STAGE BAUM JIG
1.0
    4   20     7
100.0000   3.0000   1.6250    .5000    .2500    .0930    .0460   0.0000
   .8432    .8488    .8526    .8601    .8836    .9137    .9400    .9729    .9908    .9936
   .9983   1.0058   1.0152   1.0293   1.0346   1.0406   1.0415   1.0425   1.0340   1.0349
  1.0000    .9970    .9870    .9793    .8800    .6990    .5000    .2230    .0800    .0640
   .0470    .0320    .0190    .0060    .0030   0.0000   0.0000   0.0000   0.0000   0.0000
   .8463    .8529    .8606    .9015    .9120    .9225    .9292    .9530    .9730    .9787
   .9892    .9987   1.0159   1.0340   1.0454   1.0559   1.1131   1.1741   1.1750   1.1760
  1.0000    .9980    .9900    .9070    .8690    .8140    .7500    .5000    .3000    .2500
   .2010    .1690    .1290    .0970    .0830    .0750    .0350   0.0000   0.0000   0.0000
   .8056    .8328    .8570    .8882    .8993    .9053    .9637   1.0070   1.0523   1.0916
  1.0976   1.1087   1.1248   1.1409   1.1651   1.2739   1.4551   1.7522   1.7532   1.7542
  1.0000    .9970    .9910    .9770    .9670    .9550    .6990    .5000    .2990    .1310
   .1130    .0930    .0750    .0650    .0570    .0340    .0150   0.0000   0.0000   0.0000
   .7999    .8248    .8486    .8767    .9016    .9156   1.0097   1.0810   1.1761   1.1880
  1.2096   1.2453   1.2864   1.3318   1.4118   1.5329   1.6788   1.8377   1.8388   1.8399
  1.0000    .9970    .9890    .9710    .9450    .9220    .6810    .5000    .2750    .2550
   .2290    .1970    .1690    .1450    .1150    .0860    .0610    .0400    .0400    .0400
   .7093    .7467    .7934    .8258    .8528    .8798    .8986    .9568   1.0400   1.1055
  1.1710   1.1960   1.2158   1.2501   1.2958   1.3624   1.4414   1.5558   1.7763   2.0800
  1.0000    .9950    .9850    .9760    .9520    .9310    .8990    .7330    .5000    .3660
   .2550    .2170    .1940    .1680    .1420    .1140    .0880    .0620    .0280   0.0000
   .7653    .7891    .8096    .8302    .8453    .8691    .9275    .9751   1.0810   1.1264
  1.1449   1.1718   1.2129   1.2734   1.4745   1.5372   1.6129   1.7318   1.8982   2.0539
  1.0000    .9960    .9900    .9803    .9690    .9370    .8400    .7390    .5000    .3970
   .3690    .3370    .2970    .2500    .1190    .0890    .0640    .0380    .0180    .0100
```

FIGURE I-6-3.2. (Continued)

```
   .7656    .7968    .8385    .8880    .9374    .9635   1.0156   1.1497   1.3020   1.3619
  1.3853   1.4244   1.4921   1.6171   1.7421   1.9406   2.1848   2.6040   2.6053   2.6066
  1.0000    .9980    .9900    .9750    .9480    .9250    .8730    .7020    .5000    .4220
   .4000    .3760    .3430    .2980    .2670    .2290    .1930    .1430    .1430    .1430
    6    5                                    TWO-STAGE BAUM JIG
1.0
    4   20    7
100.0000   3.0000   1.6250    .5000    .2500    .0930    .0460   0.0000
   .8432    .8488    .8526    .8601    .8836    .9137    .9400    .9729    .9908    .9936
   .9983   1.0058   1.0152   1.0293   1.0340   1.0406   1.0415   1.0425   1.0340   1.0349
  1.0000    .9970    .9870    .9790    .9530    .6990    .5000    .2230    .0800    .0640
   .0470    .0320    .0190    .0060    .0030   0.0000   0.0000   0.0000   0.0000   0.0000
   .8463    .8529    .8606    .9015    .9120    .9225    .9292    .9530    .9730    .9787
   .9892    .9987   1.0159   1.0340   1.0454   1.0559   1.1131   1.1741   1.1750   1.1760
  1.0000    .9980    .9900    .9070    .8690    .8140    .7500    .5000    .3000    .2500
   .2010    .1690    .1290    .0970    .0830    .0750    .0350   0.0000   0.0000   0.0000
   .8056    .8328    .8570    .8882    .8993    .9053    .9637   1.0070   1.0523   1.0916
  1.0976   1.1087   1.1248   1.1409   1.1651   1.2739   1.4551   1.7522   1.7532   1.7542
  1.0000    .9970    .9910    .9770    .9670    .9550    .6990    .5000    .2990    .1310
   .1130    .0930    .0750    .0650    .0570    .0340    .0150   0.0000   0.0000   0.0000
   .7999    .8248    .8486    .8767    .9016    .9156   1.0097   1.0810   1.1761   1.1880
  1.2096   1.2453   1.2864   1.3318   1.4118   1.5329   1.6788   1.8377   1.8388   1.8399
  1.0000    .9970    .9890    .9710    .9450    .9220    .6810    .5000    .2750    .2550
   .2290    .1970    .1690    .1450    .1150    .0860    .0610    .0400    .0400    .0400
   .7093    .7467    .7904    .8258    .8528    .8798    .8986    .9568   1.0400   1.1055
  1.1710   1.1960   1.2158   1.2501   1.2958   1.3624   1.4414   1.5558   1.7763   2.0800
  1.0000    .9950    .9850    .9700    .9520    .9310    .8990    .7330    .5000    .3660
   .2550    .2170    .1940    .1680    .1420    .1140    .0880    .0620    .0280   0.0000
   .7653    .7891    .8086    .8302    .8453    .8691    .9275    .9751   1.0810   1.1264
  1.1448   1.1718   1.2129   1.2734   1.4745   1.5372   1.6129   1.7318   1.8982   2.0539
  1.0000    .9960    .9900    .9800    .9690    .9370    .8400    .7390    .5000    .3970
   .3690    .3370    .2970    .2500    .1190    .0890    .0640    .0380    .0180    .0100
   .7656    .7968    .8385    .8880    .9374    .9635   1.0156   1.1497   1.3020   1.3619
  1.3853   1.4244   1.4921   1.6171   1.7421   1.9400   2.1848   2.6040   2.6053   2.6066
  1.0000    .9980    .9900    .9750    .9480    .9250    .8730    .7020    .5000    .4220
   .4000    .3760    .3430    .2980    .2670    .2290    .1930    .1430    .1430    .1430
    4   20    7
100.0000   3.0000   1.6250    .5000    .2500    .0930    .0460   0.0000
   .8296    .8345    .8538    .8667    .8850    .8957    .9086    .9301    .9709    .9988
  1.0267   1.0740   1.1234   1.1814   1.2297   1.2845   1.3898   1.5347   1.6840   2.0406
  0.0000    .0017    .0101    .0226    .0507    .0922    .1906    .3115    .4707    .5475
   .5645    .5000    .4370    .3800    .3450    .3160    .2730    .2330    .1980    .1320
   .8249    .8435    .8719    .8927    .9058    .9190    .9408    .9638   1.0940   1.1224
  1.1618   1.2078   1.2800   1.4003   1.5863   1.9003   2.1880   2.1891   2.1902   2.1913
  0.0000   0.0000    .0166    .0426    .0658    .0896    .1837    .3331    .4573    .4425
   .4314    .4000    .3620    .3090    .2430    .1490    .0680    .0680    .0680    .0680
   .8173    .8452    .8731    .9009    .9242    .9404   1.0542   1.1610   1.1749   1.2028
  1.2376   1.3050   1.3862   1.5441   1.8274   2.3220   2.3232   2.3243   2.3255   2.3266
  0.0000    .0021    .0095    .0245    .0619    .1097    .3734    .4266    .4258    .4189
   .4020    .3738    .3439    .2950    .2274    .1188    .1188    .1188    .1188    .1188
   .7948    .8301    .8437    .8618    .9195    .9560   1.0342   1.1340   1.1884   1.2100
  1.2599   1.3290   1.3926   1.4878   1.5547   1.8144   2.0412   2.2680   2.2691   2.5678
  0.0000   0.0000    .0040    .0150    .0799    .1354    .2679    .3680    .3883    .3834
   .3576    .3304    .3168    .3011    .2904    .2583    .2355    .2036    .2034    .1748
   .7187    .7359    .7632    .7950    .8247    .8533    .8798    .8946    .9031    .9964
  1.0600   1.1024   1.1702   1.1989   1.2444   1.3123   1.3685   1.4946   1.6960   2.1200
```

FIGURE I-6-3.2. (Continued)

```
0.0000   .0030   .0070   .0150   .0270   .0430   .0650   .0840   .1010   .3400
 .5000   .5770   .6870   .7170   .7480   .7860   .8090   .8510   .8910   .9370
 .7970   .8192   .8369   .8480   .8568   .9686  1.1070  1.1646  1.2077  1.2553
1.3173  1.3981  1.5155  1.6516  1.8277  2.0491  2.2140  2.2151  2.2162  2.2173
0.0000   .0050   .0120   .0200   .0310   .2410   .5000   .6000   .6590   .7090
 .7590   .8050   .8500   .8830   .9050   .9200   .9250   .9250   .9250   .9250
 .8016   .8350   .8631   .9325  1.0154  1.0568  1.1075  1.2318  1.3360  1.3894
1.4656  1.5711  1.7128  1.8811  2.0775  2.6720  2.6733  2.6747  2.6760  2.6773
0.0000   .0050   .0150   .0530   .1030   .1350   .1750   .3590   .5600   .5510
 .5950   .6370   .6790   .7170   .7520   .8400   .8400   .8400   .8400   .8400
  7    6                                  FROTH FLOTATION CELL
1.0
  2   20     7
 .8280   .8800   .8900   .9000   .9140   .9240   .9330   .9380   .9530   .9700
1.0000  1.0310  1.0660  1.0710  1.0800  1.0900  1.1060  1.1110  1.3000  1.5000
1.0000   .9930   .9870   .9780   .9600   .9400   .9200   .9000   .8000   .6900
 .5000   .3000   .0800   .0600   .0430   .0330   .0260   .0230   .0110  0.0600
 .8340   .8560   .8700   .8800   .8900   .9020   .9100   .9370   .9490   .9700
1.0000  1.0350  1.0450  1.0690  1.0900  1.1160  1.1400  1.1680  1.2000  1.5560
1.0000   .9970   .9930   .9870   .9770   .9630   .9480   .9000   .8000   .6750
 .5000   .3000   .2400   .1800   .0930   .0600   .0400   .0260   .0180  0.0000
 .7850   .8560   .8650   .8850   .9000   .9200   .9300   .9750  1.0000  1.0500
1.0800  1.0950  1.1200  1.1500  1.2000  1.2600  1.7000  1.8000  1.9000  2.0000
1.0000   .9970   .9940   .9810   .9630   .9200   .8800   .6350   .5000   .2790
 .1480   .1000   .0680   .0460   .0250   .0180  0.0000  0.0000  0.0000  0.0000
 .7590   .8200   .8300   .8500   .8650   .8750   .8900   .9100   .9300  1.0000
1.0700  1.0900  1.1200  1.1600  1.2050  1.3250  1.4750  1.6690  1.8060  2.0000
1.0000   .9930   .9910   .9830   .9720   .9620   .9390   .8870   .8170   .5000
 .2460   .1950   .1450   .1030   .0730   .0400   .0150  0.0000  0.0000  0.0000
 .7310   .7600   .7800   .8080   .8400   .8620   .9060  1.0000  1.1200  1.1600
1.2060  1.2600  1.3000  1.3600  1.5030  1.8000  2.0000  2.0500  2.1000  2.1500
1.0000   .9940   .9870   .9680   .9320   .9000   .8000   .5000   .2000   .1350
 .0990   .0660   .0520   .0400   .0260   .0210   .0200   .0200   .0200   .0200
 .6630   .7200   .7800   .8200   .8620   .8880   .9160  1.0000  1.0260  1.0400
1.0790  1.1200  1.2200  1.2400  1.2700  1.3200  1.3800  2.0000  2.0500  2.1000
1.0000   .9770   .9410   .9080   .8620   .8230   .7580   .5000   .4200   .3750
 .3000   .2370   .1000   .0800   .0600   .0400   .0300   .0200   .0200   .0200
 .6060   .6400   .6800   .7240   .7600   .8000   .8360   .8520   .9000  1.0000
1.0600  1.1240  1.2000  1.3200  1.4000  1.6000  2.0000  2.0500  2.1000  2.1500
1.0000   .9980   .9920   .9810   .9690   .9470   .9190   .9000   .8000   .5000
 .4000   .3390   .2920   .2430   .2190   .1770   .1200   .1200   .1200   .1200
 11    7                                  ROTARY BREAKER
   1.3      7.0     40.0     50.0      6.0
  1    99    1
0.20     0.20     0.20     0.20     0.20     0.20     0.20     0.20     0.20     0.20
0.20     0.20     0.08     0.08     0.08     0.08     0.08     0.08     0.08     0.08
0.08     0.08     0.08     0.08     0.06     0.06     0.06     0.06     0.06     0.06
0.06     0.06     0.06     0.06     0.06     0.06     0.05     0.05     0.05     0.05
0.05     0.05     0.05     0.05     0.05     0.05     0.05     0.05     0.05     0.05
0.05     0.05     0.05     0.05     0.05     0.05     0.05     0.05     0.05     0.05
0.05     0.05     0.05     0.05     0.05     0.05     0.05     0.05     0.05     0.05
0.05     0.05     0.05     0.05     0.05     0.05     0.05     0.05     0.05     0.05
0.05     0.05     0.05     0.05     0.05     0.05     0.05     0.05     0.05     0.05
0.05     0.05     0.05     0.05     0.05     0.05     0.05     0.05     0.05
  1    99    1
0.005    0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
```

FIGURE I-6-3.2. (Continued)

```
0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
   12     8                                   PRIMARY MULTIPLE ROLL CRUSHER
0.85     1.7      8.0
    2    11     1
1.0      0.8308   0.5882   0.4176   0.2065   0.1041   0.0522   0.0368   0.0260   0.0131
0.0
1.0      0.95     0.85     0.65     0.35     0.22     0.14     0.11     0.09     0.03
0.0
   13     8                                   PRIMARY GYRATORY/JAW CRUSHER
0.85     1.7      8.0
    2    11     1
1.0      0.8308   0.5882   0.4176   0.2065   0.1041   0.0522   0.0368   0.0260   0.0131
0.0
1.0      0.95     0.85     0.70     0.35     0.20     0.19     0.17     0.12     0.08
0.0
   14     8                                   PRIMARY SINGLE ROLL CRUSHER
0.85     1.7      8.0
    2    11     1
1.0      0.8308   0.5882   0.4176   0.2065   0.1041   0.0522   0.0368   0.0260   0.0131
0.0
1.0      0.96     0.79     0.45     0.20     0.10     0.05     0.03     0.02     0.0
0.0
   15     8                                   PRIMARY CAGE MILL CRUSHER
0.85     1.7      8.0
    2    11     1
1.0      0.8308   0.5882   0.4176   0.2065   0.1041   0.0522   0.0368   0.0260   0.0131
0.0
1.0      0.84     0.50     0.32     0.15     0.052    0.019    0.011    0.0066   0.002
0.0
   16     8                                   SECONDARY MULTIPLE ROLL CRUSHER
0.85     1.7      2.0
    2    11     1
1.0      0.8308   0.5882   0.4176   0.2065   0.1041   0.0522   0.0368   0.0260   0.0131
0.0
1.0      0.95     0.85     0.65     0.35     0.22     0.14     0.11     0.09     0.03
0.0
   17     8                                   SECONDARY GYRATORY/JAW CRUSHER
0.85     1.7      2.0
    2    11     1
1.0      0.8308   0.5882   0.4176   0.2065   0.1041   0.0522   0.0368   0.0260   0.0131
0.0
1.0      0.95     0.85     0.70     0.35     0.20     0.19     0.17     0.12     0.08
0.0
   18     8                                   SECONDARY SINGLE ROLL CRUSHER
0.85     1.7      2.0
    2    11     1
1.0      0.8308   0.5882   0.4176   0.2065   0.1041   0.0522   0.0368   0.0260   0.0131
0.0
```

FIGURE I-6-3.2. (Continued)

```
1.0      0.96     0.79     0.45     0.20     0.10     0.05     0.03     0.02     0.0
0.0                                          SECONDARY CAGE MILL CRUSHER
   18       8
0.85     1.7      2.0
    2      11        1
1.0      0.8308   0.5882   0.4176   0.2065   0.1041   0.0522   0.0368   0.0260   0.0131
0.0
1.0      0.94     0.50     0.32     0.15     0.052    0.019    0.011    0.0066   0.002
0.0
```

FIGURE I-6-3.2. (Continued)

6.3.2 Equipment Type Definition Card

The first card in each equipment type subsegment of the inventory segment of the input deck is the equipment type definition card. The purpose of this card is to supply the basic definition of the equipment type being described. This definition contains three distinct components: first, the equipment type identifier; second, the unit operation used to simulate the equipment type; third, a flag to control prebreakage in the unit: and fourth, a description of the equipment type.

The equipment type identifier is used to refer to that equipment type at other places in the input deck. In particular, the equipment type of actual units within the plant configuration is indicated via this identifier. The identifiers also appear in the two unit summary reports along with a descriptor. This can be seen on pages 1 and 67 of the user handbook example printout in Appendix A (pages 154 and 220).

The unit operation code of that unit operation being used to simulate the equipment type is, of course, crucial to relating the type to the actual mathematical operations within the program. The actual codes used to refer to the unit operations are defined in Figure I-6-3.1. The organization of the remainder of this part of the chapter reflects that fact.

The prebreakage control flag determines whether the feed to the unit is to be broken prior to entering the unit. If the flag is set to zero, no prebreakage is to occur; if the flag is set to one, prebreakage will take place and information specifying the prebreakage precedes the equipment type special information.

The descriptor of the equipment serves two very important functions. Most importantly, it documents the input subsegment by labeling it. Such labels are extremely important as an aid in finding the appropriate places in an input deck when changes are needed. Secondly, this descriptor is used as the unit descriptor within a plant configuration for units of that type when no explicit unit descriptor is specified.

It should be observed that the equipment type identifiers and the equipment type descriptors match exactly those which are hardwired into the original version of the program. This convention was followed to achieve as much downward compatibility as possible with the revised version.

6.3.3 Coding Splitting and Blending Equipment

Of all the equipment-type subsegments of the equipment segment of the input deck, the simplest, by far, are those for splitting and blending equipment. Both of these subsegments consist only of the single equipment-type definition card. This is because neither operation requires any additional special information or empirical distributions. The second and third cards of Figure I-6-3.2 show the equipment type subsegments for a stream splitter and stream blender, respectively.

6.3.4 Coding Washing Equipment

In addition to the equipment-type definition information the washing equipment requires two other types of information: a special information parameter specifying a constant for one of the unit performance measures; and a set of empirical distributions - either c-generalized or nongeneralized - used for computing the size fraction specific distribution curves for that equipment type. There are five examples of washing equipment-type segments of the input deck included in Figure I-6-3.2. These correspond to the five types of washing equipment for which c-generalized curves have been constructed. There are no examples of entering nongeneralized curves in this equipment inventory.

Immediately following the washing equipment type definition card within each equipment inventory subsegment, is the washing special information card. This card contains a single real field entered in columns 1 through 8 which specifies the offset for the denominator in the calculation of imperfection, a unit performance measure. This calculation is discussed in the next chapter. Suffice to say, at this point, that its value is one or zero. For the dense-medium vessel and dense-medium cyclone, it is set to zero; while for the remaining washing equipment types, it is set to one. These settings are reflected in the listing in Figure I-6-3.2.

Following the washing special information card is that subsegment which actually defines the empirical distribution to be used in computing the distribution curve for the washing equipment type being defined. The first card of any subsegment defining an empirical distribution is the distribution definition card. This card is used to generally define the type and size of the distribution. Its first field contains the distribution type code. The possible codes which may be used in general are shown in Figure I-6-3.1. In so far as washing equipment types are concerned, only curve type 4, c-generalized distribution curve, or curve type 5, nongeneralized set of distribution curves, may be specified. The second field in the distribution definition card specifies the number of empirical points used to define each curve in the distribution, and the third field specifies the number of size fractions.

Since both curve set types 4 and 5 are size fraction specific, the next card, or cards, immediately following the distribution definition card are used to define the size fraction classification scheme. The card type used is the miscellaneous real values specification card. This card simply contains ten real fields, each eight columns wide. The sequence of values are entered successively in these fields. If more than ten values are being entered, a second card is used. This continues until all values have been entered.

All size fraction classification schemes being defined for the program are entered in the same manner. This will be described in detail here. Several later parts in this chapter will refer back to this description. As mentioned earlier, the size of a particle of irregular shape, such as a coal particle is definable in several ways. Throughout this discussion the size of a particle is the width of the square aperture through which the particle will just pass. A size fraction is a closed-open sequence of two decreasing values, say $[S_{max}, S_{min})$, i.e., a particle is said to be of that size fraction if it would pass through any square aperture whose width is greater than or equal to S_{max} and would fail to pass through any square aperture less than or equal to S_{min} in width.

A monotone decreasing sequence of n+1 values $(S_n,\ldots,S_1,S_o)$ defines a set of n size fractions $([S_n,S_{n-1}),\ldots[S_i,S_{i-1}),\ldots,[S_1,S_o))$. This sequence is referred to as a *size fraction classification scheme*. All values associated with a size fraction classification for input into the program are expressed in decimal inches, and entered in order on the miscellaneous real values specification card. If the size fraction classification scheme contains n fractions, then n+1 values must be entered. In the special case where values are being defined only for the composite and only for one size fraction, the sequence (100.0, 0.0) should be entered.

If nongeneralized distribution curves are being entered, then the next card, or cards, following the size fraction definition specify the number of curves per size fraction to be entered. These are entered via the number of curves per size fraction card. Obviously, one integer value is entered for each size fraction. Let n_s be the number of curves for size fraction s and N_s be the number of size fractions. The total number of curves N_c is clearly computed as shown in (1)

$$N_c = \sum_{s-1}^{N_s} n_s \qquad (1)$$

Still, only if nongeneralized distribution curves are being entered, the next card, or cards, following the number of curves per size fraction card specify the specific gravity of separation for each of the distribution curves to be entered. A miscellaneous real values card, or cards, is used to enter this information. The order begins with that curve which has the lowest specific gravity of separation for the largest size fraction, followed by the next lowest, and so on until all have been exhausted for the largest fraction. Then the values for the next largest fraction are entered, and so on until all have been specified.

Immediately following the size definition card, if c-generalized curves are being entered, or after the specific gravity of separation definition if nongeneralized curves are being entered, come the cards defining the actual curve points. For each curve first the independent, x-value, points are entered on a miscellaneous values specification card, or sequence thereof. Then the dependent, or y-value, points are entered in the same manner. For generalized curves they are ordered from largest size fraction to smallest. For nongeneralized curves, they are ordered as specified in the previous paragraph.

Clearly, the preceding discussion is quite complicated. The reader is encouraged to select one of the washing equipment types and to examine its input in detail. In particular, compare the values being entered to the table of values given for that equipment type in the previous chapter.

6.3.5 Coding Two-Stage Washing Equipment

The input subsegment for the two-stage washing equipment is almost identical to that for the washing equipment which was described in the previous subpart. The only difference is that two distribution curve specifications must be entered; therefore, little more will be said about this input subsegment. The only example input for a two-stage washing equipment type in Figure I-6-3.2 is that for the two-stage baum jig.

The unit performance measures computed for two-stage washing equipment are largely the same as they are for washing; therefore, the two-stage washing type definition card is followed by the washing special information card. The appropriate value for the imperfection offset of the two-stage baum jig is one.

Each distribution curve subsegment entered for the two-stage washer is identical in structure to the single curve subsegment described for the washer. The two definitions are completely independent of each other. They need not even be of the same type - c-generalized or nongeneralized. The curves defining the ratio to clean are entered first, followed directly by the curves defining the ratio to middling.

6.3.6 Coding Froth Flotation Equipment

Coding of the froth flotation equipment type requires two types of information in addition to the equipment type definition. The first is the same value for the imperfection unit performance measure as was entered for the washing and two-stage washing types. It is entered in the same manner as before on a washing special information card immediately following the froth flotation type definition card. The only example of a froth flotation equipment type is the froth flotation cell. The imperfection offset for this example is one.

The second type of information which must be entered consists of that set of generalized curves from which the froth flotation unit operation should attempt to extract an actual distribution curve giving the desired yield and percent ash. These curves are simply entered as a set of univariate distribution curves.

The distribution definition card, immediately following the washing special information card within the froth flotation equipment type subsegment of the input deck, must then specify a curve set type code of 2. The second field on this card defines the number of points per curve, and the third defines the number of curves. Following this card are the actual curve definitions entered via the miscellaneous real value cards in the same manner as the actual curves were entered for washing - the x-values followed by the y-values of the first curve, then the second curve, and so on.

6.3.7 Coding Screening Equipment

For the screening equipment only an empirical distribution is needed in addition to the screening definition card. As with washing there are two types of empirical distributions which may be defined. First, a simple distribution over mesh size which specifies the adjustment factor to be used in the general screening equation; and second, a set of explicit size classification curves, where the particular curve used is a function of mesh size.

In the case where an adjustment factor distribution is being defined the card immediately following the screening type definition card is a distribution definition card with a curve set type code of 2, which specifies that a univariate distribution is being defined. The second field on the distribution definition card specifies the number of points used to define the distribution, and the third field would contain a constant 1, since only one distribution is needed. This card is followed by a group of miscellaneous values cards (possibly only one) defining the x-points, and then a group defining the y-points. All of the screens in the user handbook example inventory are defined in this manner. The reader can compare the values entered in Figure I-6-3.2 to those presented in the tables under the screening unit operation (Part 4.3).

In the other case the screening equipment type can be defined via an explicit set of size classification curves. There are no illustrations of this type of definition in the example. This type of definition is coded as follows. Immediately following the screening type definition card is a distribution definition card which specifies a curve set type code of 3. This code indicates that a set of size classification curves are being defined. The second field on the distribution definition card specifies the number of points in each size classification curve, which in this case is also the number of size fractions into which the curves classify the flows. The third field on the card defines the number of curves. Following the distribution definition card is a miscelleneous values card defining the size fraction classification scheme as described in the part on washing. Then the card which specifies the mesh size for each classification curve is entered. This card is also a miscellaneous values card. The mesh sizes should be specified in monotone increasing order. Finally the miscellaneous values cards defining the size classification curves in the same form as all other curves are placed in the input subsegment.

6.3.8 Coding Rotary Breaking Equipment

The rotary breaking equipment type has associated with it a series of special information entries and two 1-dimensional vectors. An example of a rotary breaking equipment type is included in the equipment inventory segment listing in Figure I-6-3.2. The reader is referred back to the part on the rotary breaking unit operation for a detailed discussion of the various constants and vectors entered for equipment types using the rotary breaking unit operation.

The first card after the rotary breaking type definition card is the rotary breaking special information card. The fields on this card are adequately described in Figure I-6-3.1 and the values for these fields are shown in Figure I-6-3.2. There are two distributions needed for rotary breaking equipment: the first defines the selection vector for the coal stream, and the second defines that vector for the rock stream. Each vector is introduced via a distribution definition card containing a 1 in the curve set type code column, the number of points in the distribution in the second field, and a constant 1 in the third field. Each distribution definition card is then followed by a single group of miscellaneous values cards (or possibly a single card) which specify the selection vector in order by fall number.

6.3.9 Coding Crushing Equipment

There are eight types of crushing equipment defined in the equipment inventory for the user handbook example as shown in Figure I-6-3.2. Each type requires three special information values and one empirical distribution defining the breakage function to be used for that material larger than the crushing range maximum. Given the description in Figure I-6-3.1 and I-6-3.2 and the previous discussion, the coding procedure is straightforward.

6.3.10 Coding Prebreakage Information

Four types of information are required for prebreakage. The first two cards are miscellaneous integer value cards, the first containing the number of size fractions defining the prebreakage, the second containing the power of the breakage matrix to be used. Next comes a miscellaneous real values card supplying the size fractions defining the prebreakage. Finally comes another miscellaneous real values card specifying the selection factor for prebreakage.

6.4 Defining the Configuration

Once the equipment inventory has been specified, the configuration of units of those equipment types may be defined. The coding of this configuration is trivial if the user has a clear representation of it when he is doing the coding. This discussion introduces a box flow diagram, which constitutes such a representation. The use of this notation has three major advantages. First, it simplifies the task of defining the units and flows in the desired configuration to the program. Second, since coal preparation engineers and management personnel are accustomed to evaluating circuits in terms of drawn flowsheets, this type of notation is already familiar to the potential users of the program. Third, if all users use the same notation, then the communication of configurations between users is greatly simplified.

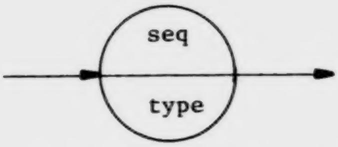
The block diagram notation contains two types of symbols - the unit block and the flow arrow. The unit block is structured as shown below. The symbol seq represents the processing sequence number of the unit. CPSM4 simulates the units in the order defined by this sequence number. Obviously the unit which accepts the feed to the plant must be assigned the sequence number of one. In addition, any unit which inputs a flow produced by another unit must have a sequence number higher than that unit. The symbol id represents the identifying code of the equipment type to which the unit belongs. This identifier must be present in the equipment inventory. The symbols D1, D2, and D3 represent the values of the decision variables to be included. The number and type of these is determined by the unit operation associated with the equipment type to which the unit belongs. Figure I-6-4.1 summarizes the decision variables by unit operation.

seq	id
D1, D2, D3	

Unit operation	Decision variable
Blending	D1 - percent moisture of output flow
Splitting	D1 - percent to upper flow
	D2 - percent moisture of upper flow
Screening	D1 - mesh size in inches
	D2 - percent moisture of upper flow
Washing	D1 - specific gravity of separation
	D2 - percent moisture of clean flow
Two-stage washing	D1 - specific gravity of separation
	D2 - percent moisture of clean flow
	D3 - percent moisture of middling flow
Froth flotation	D1 - percent moisture of clean flow
Rotary breaking	D1 - length of drum in feet
	D2 - diameter of drum in feet
	D3 - size of opening in inches
Crushing	D1 - crusher setting in inches

FIGURE 1-6-4.1. DECISION VARIABLES

The flow arrow is structured as shown below.



The type code is intended to indicate the type of output represented by the flow. Figure I-6-4.2 shows the types of codes which may be used to characterize flows.

Associated with each unit operation type are a certain set of flowstream types which must be included. These are shown in Figure I-6-4.3. The flow sequence number is used to identify the flows. It should be assigned as follows. The feed stream is assigned a sequence number of one. The flows coming out of the first unit are numbered in order by their codes, as shown in Figure I-6-4.3, and so on. Figure I-6-4.4 shows the configuration for the user handbook example. Note that the double deck screen is represented via a set of units and flows.

Type	Description
C	Clean coal stream
M	Middlings stream
R	Refuse stream
U	Screen or splitter overflow (upper) stream
L	Screen or splitter underflow (lower) stream
blank	Any other type stream

FIGURE I-6-4.2. FLOWSTREAM TYPE CODES

Unit operation	Code	Description
Blending	-	Any code may be used
Splitting	U	The output flow receiving the specified percent
	L	The output flow receiving the remainder
Screening	U	The upper (overflow) flow
	L	The lower (underflow) flow
Washing	C	The clean output flow
	R	The refuse output flow
Two-stage washing	C	The clean output flow
	R	The refuse output flow
	M	The middling output flow
Froth flotation	C	The clean output flow
	R	The refuse output flow
Rotary breaking	C	The coal output flow
	R	The refuse output flow
Crushing	-	Any code may be used

FIGURE I-6-4.3. UNIT OPERATION FLOW TYPE ASSOCIATION

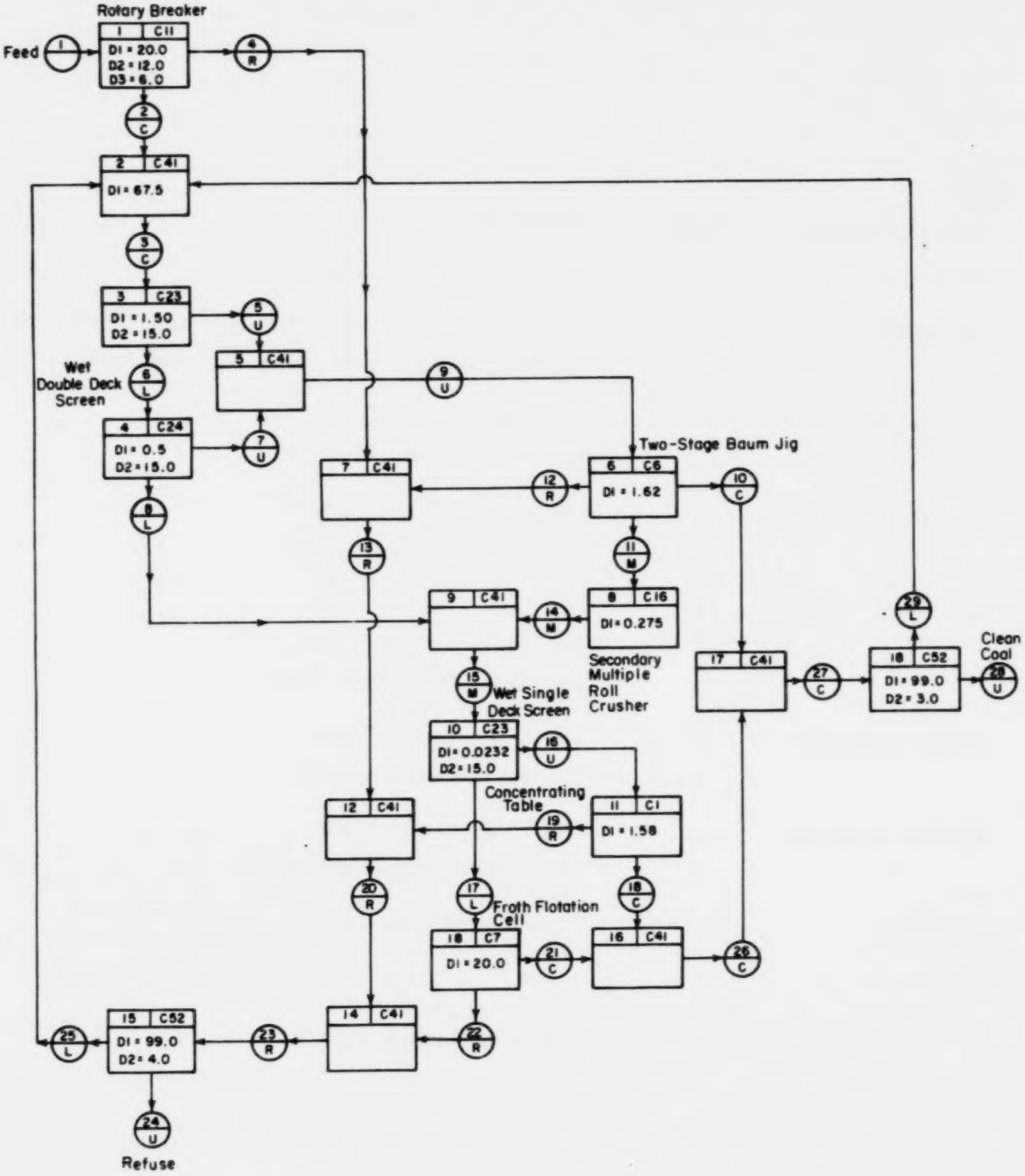

Rotary Breaker
Feed
1
1
C11
D1 = 20.0
D2 = 12.0
D3 = 6.0
4
R
2
C
2
C41
D1 = 67.5
3
C
3
C23
D1 = 1.50
D2 = 15.0
5
U
Wet
Double Deck
Screen
6
L
5
C41
9
U
4
C24
D1 = 0.5
D2 = 15.0
7
U
Two-Stage Baum Jig
7
C41
12
R
6
C6
D1 = 1.62
10
C
8
L
13
R
11
M
9
C41
14
M
8
C16
D1 = 0.275
Secondary
Multiple
Roll
Crusher
29
L
Clean
Coal
17
C41
27
C
18
C52
D1 = 99.0
D2 = 3.0
28
U
15
M
Wet Single
Deck Screen
10
C23
D1 = 0.0232
D2 = 15.0
16
U
Concentrating
Table
12
C41
19
R
11
C1
D1 = 1.58
20
R
17
L
Froth Flotation
Cell
18
C
13
C7
D1 = 20.0
21
C
16
C41
26
C
15
C52
D1 = 99.0
D2 = 4.0
25
L
23
R
14
C41
22
R
24
U
Refuse

FIGURE I-6-4.4. CONFIGURATION OF USER HANDBOOK EXAMPLE

6.5 Coding the Configuration

Once the configuration has been defined, coding it is trivial. Figure I-6-5.1 contains the field descriptions for coding the configuration. Figure I-6-5.2 shows the listing of the input describing the configuration for the user handbook example. The only limitation on configurations is that no configuration may contain more than 60 units or 100 flows. The unit cards must be arranged in order by their sequence numbers. This also holds for the flow cards.

I Configuration Key Card

Field	Type	Description
1-4	descriptive	data base configuration key

II Configuration Control Card

Field	Type	Description
1-5	integer	number of units in configuration
6-10	integer	number of flows in configuration.

III Unit Definition Card

Field	Type	Description
1-5	integer	equipment type identification code
11-20	real	value of first decision variable, if relevant
21-30	real	value of second decision variable, if relevant
31-40	real	value of third decision variable, if relevant
41-80	descriptive	description of unit.

IV Flow Definition Card

Field	Type	Description
1-5	integer	unit number of origin (0 if origin external)
6-10	integer	unit number of destination (0 if destination external)
12-12	descriptive	flow type code.

FIGURE I-6-5.1. FIELD DESCRIPTIONS FOR CONFIGURATION

```
EX1C                                         CONFIGURATICN KEY
   18   29
   11     20.0        12.0        6.0          ROTARY BREAKER
   41     67.5                                 BLENDER (ACDS WATER)
   23     1.50        15.0                     WET UPPER SCREEN
   24     0.5         15.0                     WET LOWER SCREEN
   41                                          STREAM BLENDER
    6     1.62                                 TWO-STAGE EAUM JIG
   41                                          STREAM BLENDER
   16     0.275                                SECONDARY MULTIPLE ROLL CRUSHER
   41                                          STREAM BLENDER
   23     0.0232      15.0                     WET SINGLE DECK SCREEN
    1     1.58                                 CONCENTRATING TABLE
   41                                          STREAM BLENJER
    7     20.0                                 FROTH FLOTATION CELL
   41                                          STREAM BLENCER
   52     99.0        4.0                      CENTRIFUGE
   41                                          STREAM BLENDER
   41                                          STREAM BLENDER
   52     99.0        3.0                      CENTRIFUGE
    0     1
    1     2 C
    2     3
    1     7 R
    3     5 U
    3     4 L
    4     5 U
    4     9 L
    5     6 U
    6    17 C
    6     8 M
    6     7 R
    7    12 R
    8     9 M
    9    10 M
   10    11 U
   10    13 L
   11    16 C
   11    12 R
   12    14 R
   13    16 C
   13    14 R
   14    15 R
   15     0 U
   15     2 L
   16    17 C
   17    18 C
   18     0 U
   18     2 L
                                             BLANK KEY INDICATES NO MORE CONFIGS.
```

FIGURE I-6-5.2. LISTING OF CONFIGURATION SPECIFICATION

6.6 Coding the Feed

Figure I-6-6.1 shows the field definitions to be used in coding the feed to the plant; while Figure I-6-6.2 contains the listing of the input for the user handbook example. The structure of this subsegment is straightforward. The first card is a feed control card. This is followed by a sufficient number of size fraction cards to define the feed size distribution. Then come the specific gravity fraction cards which define the specific gravity fractions. The characteristic sequence card comes next, specifying the sequence numbers of the characteristics ash, total sulfur, and Btu/lb. Following this, come as many characteristic definition cards as there are characteristics, including the flowrate or weight. These cards define the row and column headings of the characteristics for the output tables. Following this come up to thirty input feed subsegments.

The first card in each input feed subsegment is the feed key card specifying the key for the feed on the data base. If the key is blank, the last input feed subsegment has been processed. Next comes the input feed control card followed by the size fraction weight card specifying the relative weights of each size fraction in the feed. If the Btu control code is zero, the Btu values for the various specific gravity fractions are entered next. Following this come the individual feed fraction characteristics on flow value cards. The ordering of the characteristics is that given by the characteristic definition cards with the proviso that the flowrate or weight must be the first characteristic. If the missing size fraction code is 1, then the composite characteristics of the smallest size fraction are entered next. If the Btu control code is 2 there follow three cards specifying the number of points given for interpolation, and the ash and Btu values for interpolation. This completes the cards in an input feed subsegment.

I Feed Control Card

Field	Type	Description
1-5	integer	number of size fractions
6-10	integer	number of specific gravity fractions
11-15	integer	number of characteristics.

II Size Fraction Card

Field	Type	Description
1-8		
9-16		
17-24		
25-32		
33-40	real	these fields are used for the entry of the size fractions
41-48		
49-56		
57-64		
65-72		
73-80		

III Specific Gravity Fraction Card

Field	Type	Description
1-8		
9-16		
17-24		
25-32		
33-40	real	these fields are used for the entry of the specific gravity fractions
41-48		
49-56		
57-64		
65-72		
73-80		

FIGURE I-6-6.1. FIELD DESCRIPTIONS FOR SPECIFYING FEED

IV Characteristic Sequence Card

Field	Type	Description
1-5	integer	sequence numbers of ash in characteristic list
6-10	integer	sequence numbers of total sulfur in characteristic list
11-15	integer	sequence numbers of Btu/lb in characteristic list

V Characteristic Definition Card

Field	Type	Description
1-5	descriptive	characteristic code
7-36	descriptive	row descriptor for characteristic
38-44	descriptive	first line of column heading for characteristic
46-52	descriptive	second line of column heading for characteristic

VI Feed Key Card

Field	Type	Description
1-4	descriptive	data base feed key

VII Input Feed Control Card

Field	Type	Description
7-9	integer	missing size fraction code code meaning 0 all size fractions are included 1 smallest size fraction is to be estimated
13-15	integer	Btu control code code meaning 0 Btu values are specified by specific gravity fraction only 1 Btu values are included for all size and specific gravity fractions 2 Btu values are interpolated

VIII Size Fraction Weights Card

Field	Type	Description
1-6		
7-12		

FIGURE I-6-6.1. (Continued)

VIII (continued)

Field	Type	Description
13-18		
19-24		
25-30		
31-36		
37-42	real	these fields are used for the relative weights of each size fraction
43-48		
49-54		
55-60		
61-66		
67-72		
73-80		

IX Btu Values Card

Field	Type	Description
1-10		
11-20		
21-30		
31-40		
41-50	real	these fields are used for the entry of the Btu's per specific gravity increment if the Btu's are being specified by specific gravity fraction only.
51-60		
61-70		
71-80		

X Flow Values Card

Field	Type	Description
1-10	real	direct percent of weight
11-20		
21-30		

FIGURE I-6-6.1. (continued)

X (continued)

Field	Type	Description
31-40		
41-50		
51-60	real	these fields are used for the direct percent of each characteristic (for Btu's it is the Btu/lb).
61-70		
71-80		

XI Smallest Size Fraction Characteristic Value

Field	Type	Description
1-10		
11-20		
21-30		
31-40	real	these fields are used for the entry of the overall characteristic values for the smallest size fraction, if the smallest size fraction values are to be estimated.
41-50		
51-60		
61-70		
71-80		

XII Number of Points for Btu Interpolation Card

Field	Type	Description
1-5	integer	if the Btu's are to be interpolated using the percent ash of the coal, this card contains the number of points used in defining the Btu variation with ash.

FIGURE I-6.6.1. (Continued)

XIII Ash Values for Btu Interpolation Card

Field	Type	Description
1-10		
11-20		
21-30		
31-40	real	if the Btu values are to be interpolated, these fields contain the values of the independent variable (ash).
41-50		
51-60		
61-70		
71-80		

XIV Btu Values for Btu Interpolation Card

Field	Type	Description
1-10		
21-30		
31-40		
41-50	real	if the Btu values are to be interpolated, these fields contain the values of the dependent variable (Btu's) for the interpolation.
51-60		
61-70		
71-80		

FIGURE I-6-6.1.(continued)

```
     8     8     5
18.0    12.0     6.0      2.0      0.5      0.093   0.0232  0.0058  0.0017
     1.26     1.30     1.35     1.40     1.50     1.60     1.70     1.80     2.60
     2     4     5
WT     WEIGHT OF FLOW                       WEIGHT
ASH    ASH, PERCENT                           ASH
PS     PYRITIC SULFUR, PERCENT             PYRITIC  SULFUR
TS     TOTAL SULFUR, PERCENT                 TOTAL  SULFUR
BTU    BTU/LB, MOISTURE FREE                BTU/LB
EX1F                                          FEED KEY
           0      0
    7.2  23.6  32.8  13.4  13.3   5.7   3.3   2.7
15355.     14907.     13909.     12682.     11077.     9723.     8269.     1563.
19.7        2.8        .21        .79
11.0        4.4        .71        1.57
2.1         7.8        .98        1.59
11.3        15.4       1.10       1.60
2.1         25.0       1.44       1.84
1.9         31.5       2.90       3.50
.8          41.0       5.46       6.13
51.1        84.6       18.43      19.23
16.7        2.9        .18        .80
14.3        4.7        .62        1.22
5.3         9.4        1.05       1.65
5.3         16.7       1.52       2.08
4.1         26.7       1.97       2.47
2.1         35.1       3.23       3.78
1.2         45.7       6.07       6.56
50.3        82.9       17.00      18.14
21.30       2.8        .13        .80
11.8        4.4        .64        1.32
2.2         7.8        1.25       1.85
12.10       15.3       1.88       2.49
1.9         24.9       2.68       3.25
1.7         31.5       4.01       4.66
.70         41.0       5.55       6.30
47.9        84.6       20.13      20.98
22.0        2.4        .14        .77
19.9        4.7        .49        .99
6.9         9.6        .95        1.40
7.5         16.1       1.41       1.95
4.5         25.9       2.06       2.49
2.2         34.1       3.51       3.97
1.6         42.3       5.56       6.04
35.20       82.6       17.54      20.32
33.4        2.4        .08        .64
23.0        4.8        .11        .69
7.5         9.7        .45        .92
6.9         15.7       .65        1.17
3.2         25.7       1.48       1.86
1.8         33.8       2.79       3.60
1.5         41.4       3.97       4.04
22.4        84.2       21.09      21.89
47.8        1.8        .20        .69
19.4        4.3        .49        .99
5.9         8.8        1.00       1.50
```

FIGURE I-6-6.2. INPUT LISTING FOR FEED

```
4.9          15.4         1.50         2.02
2.3          24.4         2.20         2.67
1.4          33.3         3.45         4.06
1.1          41.7         6.28         6.73
16.9         82.8         21.02        21.72
59.0         1.8          .16          .73
12.5         6.4          .73          1.24
8.5          8.3          1.02         1.49
4.2          15.5         2.05         2.63
2.0          22.8         3.27         3.73
1.0          29.4         4.51         5.17
.6           34.3         6.44         7.22
12.2         67.7         20.43        21.41
36.4         1.2          .10          .64
24.0         2.7          .28          .84
15.6         4.2          .41          1.01
5.6          11.0         1.14         1.66
2.3          17.6         2.38         2.98
1.0          24.1         4.09         4.32
.5           32.2         7.44         8.06
14.7         67.3         25.60        26.50
                                                 BLANK KEY INDICATES NC MORE FEEDS
```

FIGURE I-6-6.2. (Continued)

6.7 Configuration and Feed Selection

The configuration and feed selection segment of the input data deck is used to select the desired configuration and input feeds from the data base. This segment is required even if the equipment inventory, configuration, and feed descriptions are supplied in coded card-image form in the input data deck. The first card in this segment is the data base key for the configuration to be used in this run. Next is the code for the number of feeds to be combined into the input feed to the plant configuration. If the number of feeds code is positive there follow the indicated number of pairs of cards specifying the data base key for each feed required and the weight or flow rate of that feed. Finally there is another card specifying the code for the number of feeds. If this code is zero, execution of the program stops after the first run. If the code equals -1, a second run of the program is desired and another complete input data deck should follow. If the code is positive then a new run is to be made using the same configuration as before but a different input feed. In this case, a second set of feed keys and weights should follow. Figure I-6-7.1 shows the field definitions to be used in coding this segment of the input data. Figure I-6-7.2 contains the listing of the input for the user handbook example.

I Configuration Key Card

Field	Type	Description
1-4	descriptive	data base key for configuration

II Feed Control Card

Field	Type	Description
1-5	integer	number of feeds code

code	meaning
-1	a new run is to be started; read in a new run control card and configuration
0	stop program execution
+n	number of feeds

III Feed Key Card

Field	Type	Description
1-4	descriptive	data base key for feed

IV Feed Flow Rate Card

Field	Type	Description
1-10	real	flow rate or weight of current feed

FIGURE I-6-7.1. FIELD DESCRIPTIONS FOR CONFIGURATION AND FEED SELECTION

```
EX1C
    1
EX1F
500.0
    0
```

FIGURE I-6-7.2. INPUT LISTING FOR CONFIGURATION AND FEED SELECTION

6.8 The Run Control

The first card in every input deck is the run control card. Figure I-6-8.1 shows the field specifications for this card. For the user handbook example, the first field contained

USER HANDBOOK EXAMPLE

while the other fields contained 0, 0, and 2, respectively,

Field	Type	Description	
1-65	descriptive	description of run to appear on heading of each output page	
66-70	integer	input control code	
		code	meaning
		0	the configuration and feed data are to be read from cards and saved on data base
		1	the configuration and feed data are to be read from data base
71-75	integer	cost component control card	
		code	meaning
		0	do not execute the cost component
		1	execute the cost component
76-80	integer	output control code	
		code	meaning
		-1	do not execute the simulation component
		0	print only unit and flow input and summary reports
		1	print above reports plus all unit performance reports and flows which are external to plant
		2	print all reports

FIGURE I-6-8.1. FIELD SPECIFICATION FOR RUN CONTROL

6.9 The Cost Component

Given the discussion in Section 5, the preparation of the input for the cost component is straightforward. There are five input formats used. Figure I-6-9.1 presents each of these in detail, while Figure I-6-9.2 shows the input deck for the User Handbook Cost Example. Other than these two figures no additional discussion seems necessary.

I. Main Cost Computation Control Card

Field	Type	Description
1-10	real	Production constant
11	integer	Production specification type code Code meaning: 0 Production constant specifies annual production of project 1 Production constant specifies annual feed to project
12	integer	Code defining output flows which are to be considered to be producing salable output Code meaning: 0 All output flows are salable 1 Only C output flows are salable 2 C and M output flows are salable 3 C, M, and R output flows are salable
13	integer	Code defining which characteristic of the coal is to be considered as the salable quantity Code meaning: 0 Coal 1 Heat content 2 Ash content 3 Pyritic sulfur content 4 Total sulfur content
14-23	real	Btu/lb to heat unit conversion factor
24-28	integer	Length of construction period
29-33	integer	Length of operational period
34-36	integer	Number of table functions
37-40	integer	Number of cost scenarios
41-60	descriptive	Units used to define costs
61-80	descriptive	Units used to define production

II. Table function definition card

Field	Type	Description
1-5	integer	Table function identifier
6-10	integer	Table function interpolation type code Code meaning: 1 Use linear interpolation 2 Use 4-point Lagrangian interpolation
11-15	integer	Number of points defining function

FIGURE I-6-9.1. FIELD DESCRIPTIONS FOR CODING COST COMPONENT

III. Table function values card

Field	Type	Description
1-10 11-20 21-30 31-40 41-50 51-60 61-70 71-80	real	Enter table function values

IV. Cost element definition

1-3	integer	Cost element identifier
4	integer	Level of detail code
5	integer	Element type code Code meaning: 0 Temporary value needed for computation 1 Annual production value 2 Depreciable capital investment 3 Nondepreciable capital investment 4 Operating expense 5 Depreciation 6 Other tax allowance
6-8	integer	Initial time value in CFD into which element value is to be added. If blank use default.
9-11	integer	Final time value in CFD into which element value is to be added. If blank use default.
12	integer	Cost calculation argument type code Code meaning: 0 Argument is first constant 1 Argument is value of some other cost 2 Argument is amount of material in flow 3 Argument is Btu's in coal 4 Argument is ash in coal 5 Argument is pyritic sulfur in flow 6 Argument is total sulfur in flow
13-15	integer	Number of flowstream or identifier of cost element to which argument relates.
16	integer	Cost calculation type code Code meaning: 0 Cost equals argument 1 Cost equals argument multiplied times second constant 2 Cost equals argument raised to power of second constant 3 Cost is value of table function

FIGURE I-6-9.1. (Continued)

IV. Cost element definition (continued)

Field	Type	Description
17-19	integer	Table function identifier
21-30	real	First constant
31-40	real	Second constant
41-80	descriptive	Description of cost element

V. Cost scenario control card

Field	Type	Description
1	integer	Type of profitability measure to be used Code meaning: 0 Discounted cash flow
2	integer	Depreciation type to be used Code meaning: 0 Depreciation handled by cost elements 1 Straight line
3	integer	Production assumption code Code meaning: 0 Assume constant annual production
4-5	integer	Number of cost elements to be changed
6-10	real	Rate of profit desired (ratio)
21-25	real	Income tax rate
31-80	descriptive	Scenario description

FIGURE I-6-9.1. (Continued)

```
1560000.0 110              1    10      1DOLLARS              TONS PER YEAR
 2120                                    TOTAL PREPARATION PLANT EQUIPMENT COST
  13       2  11     17500.0    .01121795 6*16 FT SINGLE DECK SCALPING SCREEN
  33       2  41     176000.0   .1116298  EIGHT CELL BAUM TYPE JIG
  43       2  61     23000.0    .04618196 6*16 FT DOUBLE DECK DEWATERING SCREENS
 203       2  51     18000.0    .03100348 5*10 FT DOUBLE DECK REFUSE SCREEN
  53       2  71     12100.0    .04878245 CRUSHER
  83       2 121     2400.0     .04333389 CLASSIFYING CYCLONE 20 INCH DIAM NIHARD
 143       2 201     1300.0     .125      HYDROCYCLONE 14 INCH DIAM RUBBER LINED
 153       2 221     12000.0    5.1282051 3*12 FT SINGLE DECK DESLIMING SCREEN
 163       2 241     23200.0    9.91453   CENTRIFUGAL DRYER
 103       2 161     28200.0    .33017211 CENTRIFUGAL DRYERS
  93       2 141     16000.0    .197047   6*16 FT SINGLE DECK DESLIMING SCREEN
 133       2 191     10000.0    .57692308 SUMP
   3       2  11     75000.0    0.0480769 PUMPS
  12                                      TOTAL CAPITAL REQUIREMENT
 222       1 211                3.0       TOTAL COST OF PREPARATION PLANT
 232                                      RAW COAL STORAGE AND HANDLING
   3           1     300000.0   1.0       RAW COAL STORAGE AREA...20000 TON CAPAC.
   3           1     520.0      200.0     RAW COAL BELT TO PLANT...42 INCH WIDE
   3           1     20000.0    1.0       TRAMP IRON MAGNET
 242                                      OTHER FACILITIES AND EQUIPMENT
   3           1     300.0      480.0     CLEAN COAL BELT....36 INCH WIDE
   3           1     350000.0   1.0       CLEAN COAL STORAGE AREA...40000 TON
   3           1     480.0      250.0     REFUSE BELT 36 INCH WIDE
   3           1     50000.0    1.0       REFUSE BIN
   3           1     150000.0   2.0       RAW COAL AND REFUSE HANDLING EQUIPMENT
   3           1     500000.0   1.0       UNIT-TRAIN LOADING FACILITY
   2                                      CONTINGENCY
   3       1 221                0.15      PREPARATION PLANT CONTINGENCY
   3       1 231                0.15      RAW COAL STORAGE CONTINGENCY
   3       1 241                0.15      OTHER FACILITIES CONTINGENCY
  14                                      OPERATING AND MAINTENANCE COST
 512       2  11     68640.0    0.044     LABOR - SUPERVISORY (NON-UNION)
 522       2  11     472680.0   0.303     LABOR - OPERATING + MAINTENANCE (UNION)
   2       1 511                0.25      FRINGE BENEFITS - NON-UNION
   2       1 521                0.21      FRINGE BENEFITS - UNION
   2       2  11     92040.0    0.059     OTHER OVERHEAD
   2       2  11     241800.0   0.155     OPERATING SUPPLIES
   2       2  11     230880.0   0.148     OPERATING MAINTENANCE
   2       2  11     209040.0   0.134     MAJOR MAINTENANCE
   2       2  11     113880.0   0.073     ELECTRICITY
   2       2  11     934440.0   0.599     SUBCONTRACT SERVICES
 -1
010   .09   1.0   0.09 0.5        USER HANDBOOK COST EXAMPLE
```

FIGURE I-6-9.2. INPUT DECK FOR USER HANDBOOK COST EXAMPLE

7.0 INTERPRETING THE OUTPUT

The output of program CPSM4 includes eight types of reports:

(1) The units input report

(2) The flows input report

(3) The specific gravity analysis of flowstream report

(4) The performance characteristics of a unit report

(5) The summary data for units report

(6) The summary data for flows report

(7) The project cash flow description

(8) The discounted cash flow analysis.

Reports 7 and 8 were discussed in detail in Section 5. This chapter describes reports 1 through 6.

The report formats themselves are largely as they were in the original version. They were designed to be as self-explanatory as possible and to follow normal conventions for reporting the type of information being shown.

A user-supplied descriptor and a sequential page number appears at the upper right-hand corner of each page of output. This convention was added in the present version to simplify identifying the output.

7.1 The Units Input Report

The first table normally printed by the program is the units input report. The purpose of this report is to echo back to the user the units specification as interpreted by the program. This report is issued prior to the running of the actual simulation. It contains no calculations. It is needed to aid the user in making certain that he has correctly specified his units and configuration.

7.2 The Flows Input Report

The second table normally printed by the program is the flows input report. The purpose of this report is to echo back to the user the flows specification as interpreted by the program. This report is issued prior to the running of the actual simulation. It contains no calculations. It is needed to aid the user in making certain that he has correctly specified his flows and configuration.

7.3 The Flowstream Specific Gravity Analysis Report

A flowstream specific gravity analysis report can be issued for every flowstream in the configuration in the following order:

(1) The input streams being blended to form the feed to the configuration

(2) The feed to the configuration

(3) The output flows from each unit immediately following the performance characteristics report for that unit.

As discussed in the previous chapter, the user has the option to control which of these should be printed.

Chapter 3 of this section discussed how flows are represented in the program and how those representations related to a report similar to the specific gravity analysis report. That discussion will not be repeated here.

The size and relative weight are shown for each size fraction. The convention for describing sizes is that all units are in inches, unless they are explicitly suffixed with the letter M. In this case they are mesh. The relative weight of the individual size fractions is expressed in terms of their precent of the flow; for the composite, the actual weight or rate of flow is given.

7.4 The Unit Performance Characteristics Report

A unit performance characteristics report is issued for every unit in the configuration immediately after the performance of that unit has been simulated. Each report consists of two parts. The first part includes a general comparison of characteristics of the input flows versus the output flows. Each performance report contains this part. The second part relates to measuring the detailed aspects of the performance. This part varies by the unit operation type. Not every unit operation has such a second part associated with it.

The actual values reported are clearly labeled and all values are calculated in accordance with the normal conventions followed by the Bureau of Mines. Nonetheless, this discussion provides a detailed description of the calculations of the measures reported. This discussion not only serves as an explicit documentation of the values reported but also provides an excellent medium to review and consolidate the mathematical presentations given in Chapters 3 and 4 of this section. Frequent reference will also be made to the various printout tables for the user handbook example described in Chapter 2 of this section and included in Appendix A.

Many of the definitions given here and some of the discussion, especially for the washers, are taken from Geer and Yancey(11). The reader is referred to that article for additional information.

The first subpart of this discussion contains a description of the general flow characterizations which appear on every unit performance summary report. The remaining subparts describe the unit operation specific measures.

7.4.1 The General Characterization

The first set of values given in each summary of performance characteristics report is as follows for each input flow to the unit and each output flow from the unit:

(1) Screen analysis, percent

(2) The percentage of the flow that belongs to each user-supplied characteristic. For the heat content, Btu per pound moisture free is used instead of the percentage

These values are given for each size fraction and for the composite. Their calculation is straightforward, as shown in (1) below.

$$\begin{aligned} C_{t,s} &= \left(\sum_g F_{t,s,g} / \sum_g F_{1,s,g}\right) \times 100.0 \\ C_{t,c} &= \left(\sum_{s,g} F_{t,s,g} / \sum_{s,g} F_{1,s,g}\right) \times 100.0 \end{aligned} \tag{1}$$

Here $C_{t,s}$ is the percentage by weight of material that is in size fraction s and is of characteristic t. Size fraction c refers to the composite material. Note that for the screen analysis,

$$\begin{aligned} C_{1,s} &= \sum_g F_{1,s,g} / \sum_g F_{1,s,g} \times 100.0 \\ &= 100.0 \end{aligned} \tag{2}$$

Relating the summary values shown for the flows to the information shown in the specific gravity analysis reports, note that the screen analysis values for a given size fraction agrees with the percent of flow value given for that size fraction in the specific gravity analysis of the appropriate flow stream. Also, the characteristic values agree with the corresponding culumative percent values on the 100.0 percent row.

7.4.2 Screening Measures

In addition to the general flowstream characterizations, the screening performance measures include four additional quantities for each size fraction and for the composite. They are:

(1) Weight ratio, underflow to feed, percent
(2) Btu ratio, underflow to feed, percent
(3) Undersize material in overflow stream, percent
(4) Overflow material in underflow stream, percent

To illustrate the calculations, reference is made to user handbook page 33 (p. 186) which contains the summary of performance characteristics for unit number 10 - a wet single deck screen with a 28 mesh opening.

The weight ratio, underflow (lower) to feed percent is simply as shown in (3).

$$\begin{aligned} 100 \times \sum_g F_{L,1,s,g} / \sum_g F_{I,1,s,g} &= 100 \times \sum_g (1-d_s)\, F_{I,1,s,g} / \sum_g F_{I,1,s,g} \\ &= (1-d_s) \times 100 \end{aligned} \tag{3}$$

For the 100M by 325M size fraction this would be as shown in (4).

$$(17.4 \times 0.581)/(187.1 \times 0.111) \times 100 = 48.7 \tag{4}$$

This value differs slightly from the reported value of 48.9 only because of round-off errors.

The Btu ratio, underflow to feed percent is as shown in (5) for the individual size fractions. Note that L indicates the lower output flow which is the underflow.

$$\begin{aligned} 100 \times \sum_g F_{L,b,s,g} / \sum_g F_{I,b,s,g} &= 100 \times \sum_g (1-d_s)\, F_{I,b,s,g} / \sum_g F_{I,b,s,g} \\ &= (1-d_s) \times 100 \end{aligned} \tag{5}$$

Here characteristic b is used to refer to the Btu per pound.

The reader is reminded that the screening unit operation classification curve values, d_s, are specific gravity independent and that the screen unit operation exhibits characteristic invariance. As a result, the values for Btu ratio, underflow to feed percent are always identical to the value of weight ratio, percent underflow to feed for the individual size fractions. This can be verified by examining the report cited above. Notice, of course, that the same simplification does not hold for the composite since that calculation involves summing over s as well.

The calculations for undersize material in overflow stream and oversize material in the underflow stream are closely related. If a given size fraction $x = (S_{max}, S_{min})$ has a value of S_{min} which is less than the screen size, then the undersized material, in the overflow stream equals the amount of material in the overflow stream in that size fraction and the oversized material in the underflow stream is zero. Inversely, if S_{min} is greater than or equal to the screen size then the undersized material in the overflow stream is zero and the oversized material in the underflow stream equals the amount of material in the underflow stream in that size fraction. The composite values equal the sums of the individual size fraction values.

7.4.3 Washing Measures

The same measures are used for the washing, two-stage washing, and froth flotation unit operations. These will be referred to as the washing measures. Of all the unit performance measures, the washing measures are by far the most complex. They are as follows.

(1) percent actual recovery
(2) percent theoretical recovery
(3) recovery efficiency percent
(4) percent Btu recovery
(5) percent ash error
(6) float in refuse, percent in product
(7) sink in clean coal, percent in product
(8) total misplaced material, percent of feed
(9) near gravity 0.1 material, percent of feed

(10) specific gravity of separation

(11) probable error, specific gravity

(12) imperfection

(13) error area

(14) distribution, percent to washed coal, by specific gravity fraction.

The actual recovery percent is simply the material in the clean output flow as a percent of the material in the feed. This is shown mathematically in (6).

$$\left(\sum_{g} F_{C,1,s,g} / \sum_{g} F_{I,1,s,g} \times 100\right) \qquad (6)$$

Using the concentrating table as an example, shown on User Handbook Example page 37 (p. 190), the actual recovery percent value for the size fraction 1/2 by 8M is derived as shown in (7).

$$(103.0 \times .513)/(169.7 \times .449) \times 100 = 69.3 \qquad (7)$$

Given rounding errors, this is the reported value. Notice that the composite actual recovery percent is equal to the yield percent given for the concentrating table as shown on the summary data for units table. This is as expected.

The value for percent theoretical recovery is somewhat more complicated. It is based on the percent ash in the clean output stream. The theoretical recovery percent for a given size fraction or composite equals the percent of material in the feed, in the relevant fraction which has a percent ash less than or equal to the percent ash in that fraction in the clean output flow. It is estimated by plotting the cumulative percent ash versus the cumulative weight and then reading off that weight value corresponding to the percent ash for the clean.

Using linear interpolation, the value of the theoretical recovery for the 1/2 by 8M size fraction would be calculated as follows. The percent ash in that size fraction, from page 36, Appendix A (p. 189), is 6.41. Turning now to the specific gravity analysis for the feed on page 34, Appendix A (p. 187), examine the cumulative percent ash and weight columns for that size fraction. The value 6.41 is between the values of 5.53 and 6.63 which have corresponding weight percent values of 67.28 and 71.12. The calculation of theoretical recovery is

$$(71.12 - 67.28)/(6.63 - 5.53) \times (6.41 - 5.53) + 67.28 = 70.35 \qquad (8)$$

The value varies slightly from the reported value of 70.5 because the program uses a more complicated routine than linear polynomial interpolation; however, the above should adequately demonstrate the calculation.

Recovery efficiency simply equals the actual recovery divided by the theoretical recovery times 100. Btu recovery is also easy. Its calculation is

$$100 \times \left(\sum_g F_{C,b,s,g} / \sum_g F_{I,b,s,g}\right) \qquad (9)$$

Ash error is the numerical difference between the actual and theoretical ash contents of washed coal at the yield of washed coal obtained. The calculation of the theoretical ash contents of washed coal at the yield of washed coal obtained proceeds much like the calculation of theoretical recovery. It is computed by plotting the cumulative weight versus the cumulative percent ash and then reading off that ash value corresponding to the actual recovery percent for the clean. It was observed earlier that actual recovery percent and percent yield were the same. Using the same example as before, the theoretical ash value is calculated in (10)

$$(6.63 - 5.53)/(71.12 - 67.28) \times (69.4 - 67.28) + 5.53 = 6.14 \qquad (10)$$

Now, subtracting this value from the actual clean ash content percent of 6.41 gives the ash error value of 0.3 which is the reported value.

The values for float in refuse, percent in product; sink in clean coal, percent in product; and total misplaced material, percent of feed are all closely related. Their calculation is a bit complex since estimation is required; however, intuitively they are quite simple. All are based on the specific gravity of separation. The term float refers to that material whose specific gravity is less than the specific gravity of separation; while the term sink refers to that material whose specific gravity is greater than or equal to the specific gravity of separation. The notions of float in refuse and sink in clean refer to the fact that if perfect separation were achieved by the unit then all float in the feed would go to clean and all sink in the feed would go to refuse. The value float in refuse, percent in product, then, is the percent by weight of the total material in the refuse which is float. Equivalently, the value sink in clean coal, percent in product, is the percent by weight of the total material in the clean coal which is sink. In some sense, the sink in clean and float in refuse can be thought of as having been misplaced; therefore, the value total misplaced material, percent of feed, is the percent by weight of the total material in the feed which was misplaced in the output flows.

The values reported under near gravity 0.1 material, percent of feed, simply represent that percentage of material in the feed which is within ± 0.1 specific gravity units of the specific gravity of separation. The calculation itself is complex. It should be pointed out that all of the calculations of these measures make heavy use of the uniformity assumption discussed earlier primarily in terms of size fractions. The application of this assumption to specific gravity distributions is similar. To demonstrate it, the calculation of a particular value of near gravity 0.1 material is presented here. The user handbook example on page 22, Appendix A (p. 175), shows a near gravity value of 11.3 for the 6 by 2 inch size fraction. That page also shows a specific gravity of separation for that size fraction of 1.53. The near gravity range, then, is 1.43 to 1.63. The problem is to compute that proportion of the material in the feed in the 6 by 2 inch size fraction which is in the specific gravity range of 1.43 to 1.63.

Turning now to page 20 of the User Handbook Example, Appendix A (p. 173), notice that the following direct percent weight values are shown for the 6 by 2 inch size fraction for the flowstream whose destination is the jig.

Specific gravity	weight
1.40 - 1.50	11.23
1.50 - 1.60	2.91
1.60 - 1.70	2.07

(11)

The problem is to compute that percent of the material in the 1.40 - 1.50 fraction which is in the fraction 1.43 - 1.50 and to compute that percent in 1.50 - 1.70 which is 1.60 - 1.63. Using the uniformity assumption, the calculations are simply

$$(1.43 - 1.50)/(1.40 - 1.50) = .7 \qquad (12)$$
$$(1.60 - 1.63)/(1.60 - 1.70) = .3$$

These calculations are based entirely on the definitions of the specific gravity fractions. They take no characteristics of the flowstream into account. The calculation of near gravity material is now

$$(0.7 \times 11.23) + 2.91 + (0.3 \times 2.07) = 11.39 \qquad (13)$$

The difference from the reported value is due to roundoff.

The next performance measure reported for the washing, two-stage washing, and froth flotation unit operations is the specific gravity of separation. This value already has been discussed extensively.

The probable error, specific gravity, is one-half of the specific gravity interval spanned by the distribution curve in passing from the 25 percent to 75 percent recovery ordinates. To calculate this value, the program uses 4-point lagrangian interpolation over the actual distribution curve calculated. As such, the calculation is straightforward. Occasionally the results shown for this value will be slightly negative. This is of course, impossible since all distribution curves are monotone decreasing. The negatives are produced because of the manner in which interpolation is performed. Eventually, this problem should be corrected.

Imperfection is the ratio of probable error divided by the specific gravity of separation or by the specific gravity of separation minus one. As discussed in the previous chapter, the offset for the denominator of the imperfection calculation is specified by the user in the equipment inventory definition.

Error area is based on the notion of perfect separation, much as the notions of float and sink were; however, it is based purely on the shape of the distribution curve. Geer and Yancey(11) describe its calculation as follows (page 18-12):

> "Since the distribution curve for a perfect separation would show all material lighter than the specific gravity of separation reporting to washed coal and all heavier material reporting to refuse, it would be composed of three straight-line segments. One segment would be on the 100-percent recovery axis, one would comprise the specific gravity of separation abscissa, and the third would lie on the 0 percent recovery axis. The area lying between this curve for a perfect separation and the distribution curve actually obtained is, like probable error, a measure of sharpness of the separation."

This area is called error area. Its physical calculation is complex and will not be described here.

The remaining values shown are the actual distribution curve values, shown as percentages, which were used for the separation. The computation is these values has been described extensively in previous parts of this report.

7.4.4 Rotary Breaking Measures

There are three unit operation specific performance measures associated with the rotary breaking.

(1) coal product/coal feed, percent
(2) coal in overflow stream, percent
(3) rock in underflow stream, percent

The first measure is 1 minus the proportion of material that will not pass through the holes in the breaker times 100. It is, thus, equivalent to the weight ratio underflow to feed percent value reported for the screening unit operations. The coal in the overflow stream is that percent of the refuse stream which is coal and the rock in the underflow stream is that percent of the clean stream which is rock.

7.5 Summary Data for Units Reports

The summary data for units report is intended to describe the overall results of the simulation for the units. It is issued after the simulation has been run. In addition to the basic unit description, it shows the yield and Btu recovery, both in percent form, for each unit.

7.6 Summary Data for Flowstreams Report

The summary data for flowstreams report is intended to describe the overall results of the simulation for the flows. It is issued after the simulation has been run. Its content is self-explanatory.

8.0 REFERENCE LIST FOR VOLUME I

(1) Gottfried, B.S., Jacobsen, P.S., and Vaillant, A., "Computer Analysis of Coal Plant Performance", presented at the 14th International Symposium on the Application of Computer Methods in the Mineral Industries, The Pennsylvania State University, Pittsburgh, Pennsylvania, (October 1976).

(2) Humphreys, K.K., Leonard, J.W., and Buttermore, J.A., "Computers for Coal-Part X", Coal Age,

(3) Isaacs, G.A., Letter dated 10/5/76 containing output data from two coal programs and a description of the cleaning plant configuration index used, PEDCo-Environmental Specialists, Inc., Cincinnati, Ohio.

(4) Walter, A.D., "A Computer Simulation Model for Coal Preparation Plant Design and Control", Unpublished Master's of Engineering Thesis, Pennsylvania State University, Department of Mineral Engineering, Pittsburgh, Pennsylvania, 1976.

(5) Holt, E.C., Jr., "An Engineering/Economic Analysis of Coal Preparation Plant Operation and Cost", Report for U.S. Department of Energy, Contract ET-75-C-01-9025, The Hoffman-Muntner Corp., Silver Spring, MD (February 1978).

(6) Vaillant, A., "Modelling Crushers, Breakers, and Screens for Use in Computer Simulation of Coal Preparation Plants", Report for U.S. Bureau of Mines, Grant GO-155030.

(7) Gottfried, B.S., "A Generalization of the Distribution Data for Characterizing the Performance of Float-Sink Coal Cleaning Devices", Unpublished paper, University of Pittsburgh, Pittsburgh, Pennsylvania.

(8) Gottfried, B.S. and Jacobsen, P.S., "A Generalized Distribution Curve for Characterizing the Performance of Coal Cleaning Equipment", Bureau of Mines RI (in preparation).

(9) Deurbrouck, A.W. and Hudy, J., "Performance Characteristics of Coal-Washing Equipment: Dense-Medium Cyclones", U.S. Bureau of Mines, RI 7673, 1972.

(10) Broadbent, S.R. and Calcott, T.G., "Coal Breakage Processes", Journal of the Institute of Fuel, London, England, December, 1956.

(11) Coal Preparation, Edited by J.W. Leonard and D.R. Mitchell, AIME, (Geer, M.R. and Yancey, H.F.) "Plant Performance and Forecasting Cleaning Results", New York (1968), Chapter 18, pp 18-1 through 18-29.

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APPENDIX A

USER HANDBOOK EXAMPLE

```
                                                                                        USER HANDBOOK EXAMPLE PAGE 1
UNIT NUMBER                       UNIT TYPE                      DECISION VARIABLES

     1                    11 (ROTARY BREAKER)                 20.000  12.000   6.000

     2                    41 (BLENDER (ADDS WATER))

     3                    23 (WET UPPER SCREEN)                        1.500

     4                    24 (WET LOWER SCREEN)                        0.500

     5                    41 (STREAM BLENDER)

     6                     6 (TWO-STAGE BAUM JIG)                      1.620

     7                    41 (STREAM BLENDER)

     8                    16 (SECONDARY MULTIPLE ROLL CRUSHER)         0.275

     9                    41 (STREAM BLENDER)

    10                    23 (WET SINGLE DECK SCREEN)                  0.023

    11                     1 (CONCENTRATING TABLE)                     1.580

    12                    41 (STREAM BLENDER)

    13                     7 (FROTH FLOTATION CELL)

    14                    41 (STREAM BLENDER)

    15                    52 (CENTRIFUGE)                             99.000

    16                    41 (STREAM BLENDER)

    17                    41 (STREAM BLENDER)

    18                    52 (CENTRIFUGE)                             99.000
```

```
                                                                              USER HANDBOOK EXAMPLE PAGE 2

FLOWSTREAM NUMBER            ORIGIN - UNIT NUMBER            DESTINATION - UNIT NUMBER
      1  (FEED)                      0                                1
      2                              1   C                            2
      3                              2                                3
      4                              1   R                            7
      5                              3   U                            5
      6                              3   L                            4
      7                              4   U                            5
      8                              4   L                            9
      9                              5   U                            6
     10                              6   C                           17
     11                              6   M                            8
     12                              6   R                            7
     13                              7   R                           12
     14                              8   M                            9
     15                              9   M                           10
     16                             10   U                           11
     17                             10   L                           13
     18                             11   C                           16
     19                             11   R                           12
     20                             12   R                           14
     21                             13   C                           16
     22                             13   R                           14
     23                             14   R                           15
     24                             15   U                            0
     25                             15   L                            2
     26                             16   C                           17
```

```
                                                                                USER HANDBOOK EXAMPLE PAGE 3
 FLOWSTREAM NUMBER           ORIGIN - UNIT NUMBER           DESTINATION - UNIT NUMBER
         27                          17   C                          18
         25                          18   U                           0
         29                          18   L                           2
```

```
                                        SPECIFIC GRAVITY ANALYSIS OF FLOWSTFEAM NUMBER 1

FEED TO UNIT NUMBER 1

                                            SPECIFIC             DIRECT, PERCENT                                    CUMULATIVE, PERCENT
      SIZE FRACTION AND WEIGHT              GRAVITY     WEIGHT    ASH  PYRITIC   TOTAL   BTU/LB        WEIGHT    ASH  PYRITIC   TOTAL   BTU/LB
                                                                       SULFUR   SULFUR                                SULFUR   SULFUR

   18 BY 12                               FLOAT-1.30    19.70    2.80    0.21    0.79   15,355          19.70    2.80    0.21    0.79   15,355
   PERCENT OF FLOW    7.1                  1.30-1.35    11.00    4.40    0.71    1.57   14,907          30.70    3.37    0.39    1.07   15,194
                                           1.35-1.40     2.10    7.80    0.98    1.59   13,909          32.80    3.66    0.43    1.10   15,112
                                           1.40-1.50    11.30   15.40    1.10    1.60   12,682          44.10    6.67    0.60    1.23   14,489
                                           1.50-1.60     2.10   25.00    1.44    1.84   11,077          46.20    7.50    0.64    1.26   14,334
                                           1.60-1.70     1.90   31.50    2.90    3.50    9,723          48.10    8.45    0.73    1.35   14,152
                                           1.70-1.80     0.80   41.00    5.46    6.13    8,269          48.90    8.98    0.80    1.42   14,056
                                           1.80-SINK    51.10   84.60   18.43   19.23    1,563         100.00   47.62    9.81   10.52    7,672

   12 BY 6                                FLOAT-1.30    16.72    2.90    0.18    0.80   15,355          16.72    2.90    0.18    0.80   15,355
   PERCENT OF FLOW   23.1                  1.30-1.35    14.31    4.70    0.62    1.22   14,907          31.03    3.73    0.38    0.99   15,148
                                           1.35-1.40     5.31    9.40    1.05    1.65   13,909          36.34    4.56    0.48    1.09   14,967
                                           1.40-1.50     5.31   16.70    1.52    2.08   12,682          41.64    6.11    0.61    1.22   14,676
                                           1.50-1.60     4.10   26.70    1.97    2.47   11,077          45.75    7.95    0.73    1.33   14,353
                                           1.60-1.70     2.10   35.10    3.23    3.78    9,723          47.85    9.15    0.84    1.44   14,150
                                           1.70-1.80     1.20   45.70    6.07    6.56    8,269          49.05   10.04    0.97    1.56   14,006
                                           1.80-SINK    50.95   82.90   17.00   18.14    1,563         100.00   47.16    9.14   10.01    7,666

   6 BY 2                                 FLOAT-1.30    21.39    2.80    0.13    0.80   15,355          21.39    2.80    0.13    0.80   15,355
   PERCENT OF FLOW   32.2                  1.30-1.35    11.85    4.40    0.64    1.32   14,907          33.23    3.37    0.31    0.99   15,195
                                           1.35-1.40     2.21    7.80    1.25    1.85   13,909          35.44    3.65    0.37    1.04   15,115
                                           1.40-1.50    12.15   15.30    1.88    2.49   12,682          47.59    6.62    0.76    1.41   14,494
                                           1.50-1.60     1.91   24.90    2.68    3.25   11,077          49.50    7.33    0.83    1.48   14,362
                                           1.60-1.70     1.71   31.50    4.01    4.66    9,723          51.20    8.13    0.94    1.59   14,208
                                           1.70-1.80     0.70   41.00    5.55    6.30    8,269          51.91    8.58    1.00    1.65   14,127
                                           1.80-SINK    48.09   84.60   20.13   20.98    1,563         100.00   45.14   10.20   10.95    8,085

   2 BY 1/2                               FLOAT-1.30    22.04    2.40    0.14    0.77   15,355          22.04    2.40    0.14    0.77   15,355
   PERCENT OF FLOW   13.1                  1.30-1.35    19.94    4.70    0.49    0.99   14,907          41.98    3.49    0.31    0.87   15,142
                                           1.35-1.40     6.91    9.60    0.95    1.40   13,909          48.90    4.36    0.40    0.95   14,968
                                           1.40-1.50     7.52   16.10    1.41    1.95   12,682          56.41    5.92    0.53    1.08   14,663
                                           1.50-1.60     4.51   25.90    2.06    2.49   11,077          60.92    7.40    0.65    1.19   14,398
                                           1.60-1.70     2.20   34.10    3.51    3.97    9,723          63.13    8.33    0.75    1.28   14,235
                                           1.70-1.80     1.60   42.30    5.56    6.04    8,269          64.73    9.17    0.86    1.40   14,087
                                           1.80-SINK    35.27   82.60   17.54   20.02    1,563         100.00   35.07    6.75    7.97    9,670

   1/2 BY 8M                              FLOAT-1.30    33.50    2.40    0.08    0.64   15,355          33.50    2.40    0.08    0.64   15,355
   PERCENT OF FLOW   13.0                  1.30-1.35    23.07    4.80    0.11    0.69   14,907          56.57    3.38    0.09    0.66   15,172
                                           1.35-1.40     7.52    9.70    0.45    0.92   13,909          64.09    4.12    0.13    0.69   15,024
                                           1.40-1.50     6.92   15.70    0.65    1.17   12,682          71.01    5.25    0.18    0.74   14,796
                                           1.50-1.60     3.21   25.70    1.48    1.86   11,077          74.22    6.13    0.24    0.79   14,635
                                           1.60-1.70     1.81   33.80    2.79    3.00    9,723          76.03    6.79    0.30    0.84   14,518
                                           1.70-1.80     1.50   41.40    3.87    4.04    8,269          77.53    7.46    0.37    0.90   14,397
                                           1.80-SINK    22.47   84.20   21.09   21.89    1,563         100.00   24.70    5.03    5.62   11,514
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                                                                                                            USER HANDBOOK EXAMPLE PAGE 5

                                             SPECIFIC GRAVITY ANALYSIS OF FLOWSTREAM NUMBER 1 (CONTINUED)

FEED TO UNIT NUMBER 1

                                          SPECIFIC                DIRECT, PERCENT                                    CUMULATIVE, PERCENT
      SIZE FRACTION AND WEIGHT            GRAVITY      WEIGHT     ASH  PYRITIC    TOTAL  BTU/LB       WEIGHT     ASH  PYRITIC    TOTAL  BTU/LB
                                                                       SULFUR   SULFUR                                SULFUR   SULFUR

    8M BY 28M                            FLOAT-1.30     47.99     1.80     0.20     0.68  15,355        47.99     1.80     0.20     0.68  15,355
    PERCENT OF FLOW    5.6                1.30-1.35     19.48     4.30     0.48     0.98  14,907        67.47     2.52     0.28     0.77  15,226
                                          1.35-1.40      5.82     8.80     1.00     1.50  13,909        73.29     3.02     0.34     0.82  15,121
                                          1.40-1.50      4.92    15.40     1.50     2.02  12,682        78.21     3.80     0.41     0.90  14,968
                                          1.50-1.60      2.31    24.40     2.20     2.67  11,077        80.52     4.39     0.46     0.95  14,856
                                          1.60-1.70      1.41    33.30     3.45     4.06   9,723        81.93     4.89     0.51     1.00  14,768
                                          1.70-1.80      1.10    41.70     6.28     6.70   8,269        83.03     5.38     0.59     1.08  14,682
                                          1.80-SINK     16.97    82.80    21.02    21.72   1,563       100.00    18.51     4.06     4.58  12,456

    28M BY 100M                          FLOAT-1.30     59.00     1.80     0.16     0.73  15,355        59.00     1.80     0.16     0.73  15,355
    PERCENT OF FLOW    3.2                1.30-1.35     12.50     6.40     0.73     1.24  14,907        71.50     2.60     0.26     0.82  15,277
                                          1.35-1.40      8.50     8.30     1.02     1.49  13,909        80.00     3.21     0.34     0.89  15,131
                                          1.40-1.50      4.20    15.50     2.05     2.63  12,682        84.20     3.82     0.43     0.98  15,009
                                          1.50-1.60      2.00    22.80     3.27     3.73  11,077        86.20     4.26     0.49     1.04  14,918
                                          1.60-1.70      1.00    28.40     4.51     5.17   9,723        87.20     4.54     0.54     1.09  14,858
                                          1.70-1.80      0.60    34.30     6.44     7.22   8,269        87.80     4.74     0.58     1.13  14,813
                                          1.80-SINK     12.20    67.70    20.43    21.41   1,563       100.00    12.42     3.00     3.60  13,197

    100M BY 325M                         FLOAT-1.30     36.36     1.20     0.10     0.64  15,355        36.36     1.20     0.10     0.64  15,355
    PERCENT OF FLOW    2.6                1.30-1.35     23.98     2.70     0.28     0.84  14,907        60.34     1.80     0.17     0.72  15,177
                                          1.35-1.40     15.58     4.20     0.41     1.01  13,909        75.92     2.29     0.22     0.78  14,917
                                          1.40-1.50      5.59    11.00     1.14     1.66  12,682        81.52     2.89     0.28     0.84  14,763
                                          1.50-1.60      2.30    17.60     2.38     2.98  11,077        83.82     3.29     0.34     0.90  14,662
                                          1.60-1.70      1.00    24.10     4.09     4.32   9,723        84.82     3.54     0.39     0.94  14,604
                                          1.70-1.80      0.50    32.20     7.44     8.06   8,269        85.31     3.70     0.43     0.98  14,567
                                          1.80-SINK     14.69    67.30    25.60    26.50   1,563       100.00    13.04     4.12     4.73  12,657

    COMPOSITE                            FLOAT-1.30     24.95     2.45     0.14     0.74  15,355        24.95     2.45     0.14     0.74  15,355
    FLOWRATE             500.0            1.30-1.35     15.65     4.57     0.49     1.09  14,907        40.61     3.27     0.28     0.88  15,182
                                          1.35-1.40      4.99     8.69     0.88     1.42  13,909        45.59     3.86     0.34     0.94  15,043
                                          1.40-1.50      8.38    15.58     1.54     2.11  12,682        53.97     5.68     0.53     1.12  14,676
                                          1.50-1.60      2.98    25.57     2.09     2.56  11,077        56.95     6.72     0.61     1.19  14,488
                                          1.60-1.70      1.83    33.08     3.47     4.00   9,723        58.78     7.54     0.70     1.28  14,340
                                          1.70-1.80      1.06    42.37     5.46     5.95   8,269        59.84     8.16     0.78     1.36  14,232
                                          1.80-SINK     40.16    83.46    18.91    20.02   1,563       100.00    38.40     8.06     8.86   9,145
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                                                                                        USER HANDBOOK EXAMPLE PAGE 6

                                  SUMMARY OF THE PERFORMANCE CHARACTERISTICS OF UNIT NUMBER  1

                                                      ROTARY BREAKER
                       LENGTH =20.00 FEET       DIAMETER = 12.00 FEET           SIZE OF OPENING =6.00 INCHES

 SIZE, INCHES OR MESH                          18       12        6        2      1/2       8M      28M     100M     COMP
                                               BY       BY       BY       BY       BY       BY       BY       BY
                                               12        6        2      1/2       8M      28M     100M     325M

 SCREEN ANALYSIS, PERCENT-
    FEED (COAL + ROCK)........................ 7.06    23.14    32.16    13.14    13.04     5.59     3.24     2.65   100.00
    UNDERFLOW (PRODUCT) STREAM................ 0.00     0.00    44.48    22.15    17.54     7.47     4.34     4.02   100.00
    OVERFLOW (REFUSE) STREAM.................23.20    76.80     0.00     0.00     0.00     0.00     0.00     0.00   100.00

 ASH, PERCENT
    FEED (COAL + ROCK)........................47.62    47.16    45.14    35.07    24.70    18.51    12.42    13.04    38.40
    UNDERFLOW (PRODUCT) STREAM................ 0.00     0.00    39.21    26.94    22.69    17.52    12.01    11.34    29.68
    OVERFLOW (REFUSE) STREAM.................97.73    94.54     0.00     0.00     0.00     0.00     0.00     0.00    95.28

 PYRITIC SULFUR, PERCENT
    FEED (COAL + ROCK)........................ 9.81     9.14    10.20     6.75     5.03     4.06     3.00     4.12     8.06
    UNDERFLOW (PRODUCT) STREAM................ 0.00     0.00    11.07    10.28     7.01     5.29     3.92     4.25     9.17
    OVERFLOW (REFUSE) STREAM.................. 0.43     0.97     0.00     0.00     0.00     0.00     0.00     0.00     0.84

 TOTAL SULFUR, PERCENT
    FEED (COAL + ROCK)........................10.52    10.01    10.95     7.97     5.62     4.58     3.60     4.73     8.86
    UNDERFLOW (PRODUCT) STREAM................ 0.00     0.00    11.95    11.52     7.79     5.93     4.57     4.88    10.07
    OVERFLOW (REFUSE) STREAM.................. 0.46     1.05     0.00     0.00     0.00     0.00     0.00     0.00     0.92

 BTU/LB, MOISTURE FREE
    FEED (COAL + ROCK)........................ 7,672    7,666    8,085    9,670   11,514   12,456   13,197   12,657    9,145
    UNDERFLOW (PRODUCT) STREAM................     0        0    8,912   10,778   11,698   12,555   13,289   13,035   10,442
    OVERFLOW (REFUSE) STREAM..................   333      795        0        0        0        0        0        0      593

 COAL PRODUCT/COAL FEED.............. PERCENT   0.0      0.0    100.0    100.0    100.0    100.0    100.0    100.0     99.0
 COAL IN OVERFLOW STREAM................ DO     2.5      5.0      0.0      0.0      0.0      0.0      0.0      0.0      5.2
 ROCK IN UNDERFLOW STREAM............... DO     0.0      0.0     33.6     19.7     15.8     11.9      7.0      7.5     23.6
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                                           SPECIFIC GRAVITY ANALYSIS OF FLOWSTREAM NUMBER 2

                                   ORIGIN - UNIT NUMBER   1   C        DESTINATION - UNIT NUMBER   2

                                      SPECIFIC                DIRECT, PERCENT                                     CUMULATIVE, PERCENT
     SIZE FRACTION AND WEIGHT         GRAVITY     WEIGHT    ASH  PYRITIC   TOTAL   BTU/LB        WEIGHT     ASH  PYRITIC   TOTAL   BTU/LB
                                                                 SULFUR  SULFUR                                  SULFUR  SULFUR

   6 BY 2                            FLOAT-1.30    22.29    2.83    0.15    0.80  15,355          22.29    2.83    0.15    0.80  15,355
   PERCENT OF FLOW  44.5              1.30-1.35    14.09    4.50    0.64    1.31  14,907          36.38    3.48    0.34    1.00  15,181
                                      1.35-1.40     3.54    8.62    1.13    1.73  13,909          39.92    3.93    0.41    1.06  15,069
                                      1.40-1.50    11.24   15.54    1.74    2.33  12,682          51.15    6.48    0.70    1.34  14,544
                                      1.50-1.60     2.92   25.77    2.24    2.77  11,077          54.07    7.52    0.79    1.42  14,357
                                      1.60-1.70     2.08   32.75    3.63    4.24   9,723          56.15    8.46    0.89    1.52  14,186
                                      1.70-1.80     0.97   42.99    5.76    6.40   8,269          57.12    9.04    0.97    1.60  14,085
                                      1.80-SINK    42.88   79.40   24.53   25.74   2,020         100.00   39.21   11.07   11.95   8,912

   2 BY 1/2                          FLOAT-1.30    25.17    2.62    0.15    0.78  15,355          25.17    2.62    0.15    0.78  15,355
   PERCENT OF FLOW  22.1              1.30-1.35    20.17    4.65    0.55    1.12  14,907          45.34    3.52    0.33    0.93  15,156
                                      1.35-1.40     6.53    9.35    1.00    1.51  13,909          51.87    4.26    0.42    1.01  14,939
                                      1.40-1.50     9.96   15.92    1.52    2.08  12,682          61.83    6.13    0.59    1.18  14,626
                                      1.50-1.60     4.66   26.02    2.06    2.52  11,077          66.49    7.53    0.70    1.27  14,377
                                      1.60-1.70     2.57   33.82    3.46    3.98   9,723          69.06    8.50    0.80    1.37  14,204
                                      1.70-1.80     1.58   43.01    5.69    6.21   8,269          70.63    9.27    0.91    1.48  14,072
                                      1.80-SINK    29.37   69.44   32.81   35.66   2,856         100.00   26.94   10.28   11.52  10,778

   1/2 BY 8M                         FLOAT-1.30    32.35    2.47    0.10    0.67  15,355          32.35    2.47    0.10    0.67  15,355
   PERCENT OF FLOW  17.5              1.30-1.35    22.79    4.76    0.22    0.81  14,907          55.14    3.41    0.15    0.73  15,170
                                      1.35-1.40     7.35    9.59    0.59    1.07  13,909          62.49    4.14    0.20    0.77  15,022
                                      1.40-1.50     8.24   15.75    0.99    1.53  12,682          70.73    5.49    0.29    0.86  14,749
                                      1.50-1.60     3.68   25.82    1.69    2.10  11,077          74.41    6.50    0.36    0.92  14,567
                                      1.60-1.70     2.09   33.75    3.03    3.36   9,723          76.50    7.24    0.43    0.99  14,435
                                      1.70-1.80     1.55   41.92    4.38    4.65   8,269          78.05    7.93    0.51    1.06  14,312
                                      1.80-SINK    21.95   75.17   30.11   31.74   2,401         100.00   22.69    7.01    7.79  11,698

   8M BY 28M                         FLOAT-1.30    44.34    1.95    0.18    0.68  15,355          44.34    1.95    0.18    0.68  15,355
   PERCENT OF FLOW   7.5              1.30-1.35    20.90    4.44    0.42    0.94  14,907          65.23    2.75    0.26    0.77  15,211
                                      1.35-1.40     6.40    9.05    0.88    1.38  13,909          71.63    3.31    0.31    0.82  15,095
                                      1.40-1.50     6.20   15.56    1.34    1.87  12,682          77.83    4.28    0.39    0.90  14,903
                                      1.50-1.60     2.84   25.00    2.02    2.48  11,077          80.67    5.01    0.45    0.96  14,768
                                      1.60-1.70     1.68   33.47    3.32    3.84   9,723          82.35    5.60    0.51    1.02  14,665
                                      1.70-1.80     1.27   41.86    5.67    6.05   8,269          83.62    6.15    0.59    1.09  14,568
                                      1.80-SINK    16.38   75.63   29.30   30.64   2,274         100.00   17.52    5.29    5.93  12,555

   28M BY 100M                       FLOAT-1.30    55.24    1.86    0.16    0.72  15,355          55.24    1.86    0.16    0.72  15,355
   PERCENT OF FLOW   4.3              1.30-1.35    15.49    5.62    0.58    1.11  14,907          70.72    2.68    0.25    0.80  15,257
                                      1.35-1.40     8.16    8.52    0.97    1.45  13,909          78.88    3.28    0.33    0.87  15,117
                                      1.40-1.50     5.08   15.55    1.73    2.29  12,682          83.96    4.03    0.41    0.96  14,970
                                      1.50-1.60     2.38   23.75    2.75    3.20  11,077          86.34    4.57    0.48    1.02  14,863
                                      1.60-1.70     1.27   30.60    3.97    4.55   9,723          87.60    4.95    0.53    1.07  14,789
                                      1.70-1.80     0.84   37.96    5.91    6.49   8,269          88.44    5.26    0.58    1.12  14,727
                                      1.80-SINK    11.56   63.69   29.52   30.96   2,287         100.00   12.01    3.92    4.57  13,289
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                                                                                                                   USER HANDBOOK EXAMPLE PAGE 8

                                                 SPECIFIC GRAVITY ANALYSIS OF FLOWSTREAM NUMBER 2 (CONTINUED)

                                              ORIGIN - UNIT NUMBER   1   C       DESTINATION - UNIT NUMBER   2

                                                    SPECIFIC                DIRECT, PERCENT                                    CUMULATIVE, PERCENT
     SIZE FRACTION AND WEIGHT                       GRAVITY     WEIGHT     ASH  PYRITIC   TOTAL   BTU/LB        WEIGHT     ASH  PYRITIC   TOTAL   BTU/LB
                                                                                SULFUR   SULFUR                                 SULFUR   SULFUR

   100M BY 325M                                    FLOAT-1.30    41.30    1.43     0.12     0.66  15,355         41.30    1.43     0.12     0.66  15,355
   PERCENT OF FLOW    4.0                           1.30-1.35    22.60    3.20     0.33     0.88  14,907         63.90    2.06     0.13     0.74  15,197
                                                    1.35-1.40    13.87    4.85     0.49     1.07  13,909         77.77    2.55     0.25     0.80  14,967
                                                    1.40-1.50     5.66   12.14     1.26     1.78  12,682         83.43    3.20     0.32     0.87  14,812
                                                    1.50-1.60     2.40   19.39     2.42     2.98  11,077         85.83    3.66     0.37     0.93  14,707
                                                    1.60-1.70     1.12   26.47     3.99     4.32   9,723         86.95    3.95     0.42     0.97  14,643
                                                    1.70-1.80     0.63   34.98     6.78     7.35   8,269         87.57    4.17     0.47     1.01  14,598
                                                    1.80-SINK    12.43   61.85    30.94    32.13   2,021        100.00   11.34     4.25     4.88  13,035

   COMPOSITE                                       FLOAT-1.30    28.53    2.45     0.14     0.74  15,355         28.53    2.45     0.14     0.74  15,355
   FLOWRATE             433.5                       1.30-1.35    17.87    4.57     0.49     1.09  14,907         46.41    3.26     0.28     0.88  15,182
                                                    1.35-1.40     5.70    8.69     0.88     1.41  13,909         52.11    3.86     0.34     0.93  15,043
                                                    1.40-1.50     9.56   15.58     1.55     2.11  12,682         61.67    5.67     0.53     1.12  14,677
                                                    1.50-1.60     3.39   25.56     2.09     2.57  11,077         65.05    6.71     0.61     1.19  14,490
                                                    1.60-1.70     2.08   33.07     3.48     4.00   9,723         67.14    7.53     0.70     1.28  14,342
                                                    1.70-1.80     1.21   42.35     5.45     5.95   8,269         68.35    8.15     0.78     1.36  14,234
                                                    1.80-SINK    31.65   76.17    27.28    28.88   2,252        100.00   29.68     9.17    10.07  10,442
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                                                                                               USER HANDBOOK EXAMPLE PAGE 9

                                                SPECIFIC GRAVITY ANALYSIS OF FLOWSTREAM NUMBER 4

                                      ORIGIN - UNIT NUMBER   1   R       DESTINATION - UNIT NUMBER   7

                                          SPECIFIC              DIRECT, PERCENT                                        CUMULATIVE, PERCENT
     SIZE FRACTION AND WEIGHT             GRAVITY    WEIGHT      ASH  PYRITIC   TOTAL   BTU/LB       WEIGHT     ASH  PYRITIC   TOTAL   BTU/LB
                                                                      SULFUR  SULFUR                                  SULFUR  SULFUR

 18 BY 12                                FLOAT-1.30    0.85     2.80     0.21     0.79  15,355         0.85     2.80     0.21     0.79  15,355
 PERCENT OF FLOW  23.2                    1.30-1.35    0.48     4.40     0.71     1.57  14,907         1.33     3.37     0.39     1.07  15,194
                                          1.35-1.40    0.09     7.80     0.98     1.59  13,909         1.42     3.66     0.43     1.10  15,112
                                          1.40-1.50    0.49    15.40     1.10     1.60  12,682         1.91     6.67     0.60     1.23  14,489
                                          1.50-1.60    0.09    25.00     1.44     1.84  11,077         2.00     7.50     0.64     1.26  14,334
                                          1.60-1.70    0.08    31.50     2.90     3.50   9,723         2.09     8.45     0.73     1.35  14,152
                                          1.70-1.80    0.03    41.00     5.46     6.13   8,269         2.12     8.98     0.80     1.42  14,056
                                          1.80-SINK   97.88    99.65     0.42     0.44      35       100.00    97.73     0.43     0.46     333

 12 BY 6                                 FLOAT-1.30    1.83     2.87     0.19     0.80  15,355         1.83     2.87     0.19     0.80  15,355
 PERCENT OF FLOW  76.8                    1.30-1.35    1.38     4.63     0.64     1.31  14,907         3.21     3.62     0.38     1.02  15,162
                                          1.35-1.40    0.45     9.17     1.04     1.64  13,909         3.66     4.31     0.47     1.09  15,008
                                          1.40-1.50    0.74    16.08     1.32     1.85  12,682         4.39     6.28     0.61     1.22  14,618
                                          1.50-1.60    0.36    26.39     1.87     2.36  11,077         4.76     7.82     0.71     1.31  14,348
                                          1.60-1.70    0.21    34.09     3.14     3.70   9,723         4.97     8.93     0.81     1.41  14,151
                                          1.70-1.80    0.11    44.65     5.93     6.46   8,269         5.08     9.72     0.92     1.52  14,021
                                          1.80-SINK   94.92    99.08     0.97     1.03      87       100.00    94.54     0.97     1.05     795

 COMPOSITE                               FLOAT-1.30    1.60     2.86     0.19     0.80  15,355         1.60     2.86     0.19     0.80  15,355
 FLOWRATE              66.5               1.30-1.35    1.17     4.60     0.65     1.33  14,907         2.77     3.60     0.39     1.02  15,166
                                          1.35-1.40    0.37     9.09     1.04     1.64  13,909         3.14     4.24     0.46     1.09  15,019
                                          1.40-1.50    0.68    15.97     1.28     1.81  12,682         3.82     6.33     0.61     1.22  14,603
                                          1.50-1.60    0.30    26.30     1.84     2.32  11,077         4.12     7.78     0.70     1.30  14,346
                                          1.60-1.70    0.18    33.82     3.11     3.68   9,723         4.30     8.88     0.80     1.40  14,151
                                          1.70-1.80    0.09    44.34     5.89     6.44   8,269         4.39     9.64     0.91     1.51  14,025
                                          1.80-SINK   95.61    99.21     0.84     0.89      75       100.00    95.28     0.84     0.92     688
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                              SPECIFIC GRAVITY ANALYSIS OF FLOWSTREAM NUMBER 3

                   ORIGIN - UNIT NUMBER   2           DESTINATION - UNIT NUMBER   3

  SIZE FRACTION AND WEIGHT     SPECIFIC            DIRECT, PERCENT                                    CUMULATIVE, PERCENT
                               GRAVITY    WEIGHT    ASH  PYRITIC   TOTAL  BTU/LB       WEIGHT     ASH  PYRITIC   TOTAL  BTU/LB
                                                         SULFUR   SULFUR                               SULFUR   SULFUR
 12 BY 6
 PERCENT OF FLOW   0.1        FLOAT-1.30    1.68    2.86    0.19    0.80  15,355        1.68    2.86    0.19    0.80  15,355
                               1.30-1.35    1.25    4.61    0.65    1.32  14,907        2.93    3.61    0.39    1.02  15,164
                               1.35-1.40    0.40    9.12    1.04    1.64  13,909        3.33    4.26    0.46    1.09  15,014
                               1.40-1.50    0.70   16.01    1.30    1.82  12,682        4.03    6.31    0.61    1.22  14,609
                               1.50-1.60    0.32   26.34    1.86    2.33  11,077        4.35    7.79    0.70    1.30  14,347
                               1.60-1.70    0.19   33.93    3.12    3.69   9,723        4.55    8.90    0.80    1.40  14,152
                               1.70-1.80    0.10   44.47    5.91    6.45   8,269        4.65    9.67    0.91    1.51  14,025
                               1.80-SINK   95.35   99.16    0.89    0.94      79      100.00   95.01    0.89    0.97     727

 6 BY 2
 PERCENT OF FLOW  44.2        FLOAT-1.30   22.29    2.83    0.15    0.80  15,355       22.29    2.83    0.15    0.80  15,355
                               1.30-1.35   14.09    4.50    0.64    1.31  14,907       36.38    3.48    0.34    1.00  15,181
                               1.35-1.40    3.54    8.62    1.13    1.73  13,909       39.91    3.93    0.41    1.06  15,069
                               1.40-1.50   11.23   15.54    1.74    2.33  12,682       51.14    6.48    0.70    1.34  14,545
                               1.50-1.60    2.91   25.78    2.24    2.77  11,077       54.06    7.52    0.78    1.42  14,358
                               1.60-1.70    2.07   32.75    3.63    4.24   9,723       56.13    8.45    0.89    1.52  14,187
                               1.70-1.80    0.97   42.99    5.76    6.40   8,269       57.10    9.04    0.97    1.60  14,086
                               1.80-SINK   42.90   79.45   24.47   25.68   2,016      100.00   39.25   11.06   11.93   8,908

 2 BY 1/2
 PERCENT OF FLOW  22.2        FLOAT-1.30   25.18    2.62    0.15    0.78  15,355       25.18    2.62    0.15    0.78  15,355
                               1.30-1.35   20.15    4.64    0.55    1.12  14,907       45.33    3.52    0.33    0.93  15,156
                               1.35-1.40    6.51    9.35    1.00    1.51  13,909       51.84    4.25    0.42    1.01  14,999
                               1.40-1.50    9.97   15.92    1.52    2.08  12,682       61.81    6.14    0.59    1.18  14,625
                               1.50-1.60    4.64   26.02    2.06    2.52  11,077       66.45    7.52    0.70    1.27  14,378
                               1.60-1.70    2.55   33.81    3.46    3.98   9,723       69.00    8.49    0.80    1.37  14,206
                               1.70-1.80    1.57   43.01    5.69    6.21   8,269       70.57    9.26    0.91    1.48  14,074
                               1.80-SINK   29.43   69.61   32.65   35.48   2,841      100.00   27.02   10.25   11.49  10,768

 1/2 BY 8M
 PERCENT OF FLOW  17.6        FLOAT-1.30   32.31    2.47    0.10    0.67  15,355       32.31    2.47    0.10    0.67  15,355
                               1.30-1.35   22.76    4.75    0.23    0.81  14,907       55.07    3.41    0.15    0.73  15,170
                               1.35-1.40    7.34    9.59    0.59    1.07  13,909       62.40    4.14    0.20    0.77  15,022
                               1.40-1.50    8.26   15.75    1.00    1.53  12,682       70.66    5.50    0.29    0.86  14,748
                               1.50-1.60    3.68   25.82    1.69    2.10  11,077       74.34    6.50    0.36    0.92  14,567
                               1.60-1.70    2.09   33.75    3.03    3.36   9,723       76.43    7.25    0.44    0.99  14,434
                               1.70-1.80    1.55   41.92    4.39    4.66   8,269       77.97    7.93    0.52    1.06  14,312
                               1.80-SINK   22.03   75.21   30.04   31.67   2,397      100.00   22.75    7.02    7.80  11,687

 8M BY 28M
 PERCENT OF FLOW   7.6        FLOAT-1.30   43.91    1.95    0.18    0.68  15,355       43.91    1.95    0.18    0.68  15,355
                               1.30-1.35   20.75    4.44    0.41    0.94  14,907       64.67    2.75    0.26    0.77  15,211
                               1.35-1.40    6.35    9.05    0.88    1.38  13,909       71.02    3.31    0.31    0.82  15,095
                               1.40-1.50    6.21   15.56    1.34    1.87  12,682       77.23    4.30    0.39    0.91  14,901
                               1.50-1.60    2.87   25.02    2.03    2.48  11,077       80.11    5.04    0.45    0.96  14,764
                               1.60-1.70    1.72   33.46    3.33    3.85   9,723       81.83    5.64    0.51    1.02  14,657
                               1.70-1.80    1.29   41.88    5.66    6.05   8,269       83.11    6.20    0.59    1.10  14,559
                               1.80-SINK   16.89   75.68   29.19   30.54   2,272      100.00   17.93    5.42    6.07  12,484
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                                                                                                      USER HANDBOOK EXAMPLE PAGE 11

                                   SPECIFIC GRAVITY ANALYSIS OF FLOWSTREAM NUMBER 3 (CONTINUED)

                               ORIGIN - UNIT NUMBER   2          DESTINATION - UNIT NUMBER   3

                                      SPECIFIC              DIRECT, PERCENT                                  CUMULATIVE, PERCENT
     SIZE FRACTION AND WEIGHT         GRAVITY     WEIGHT    ASH  PYRITIC   TOTAL  BTU/LB        WEIGHT    ASH  PYRITIC  TOTAL  BTU/LB
                                                                 SULFUR   SULFUR                               SULFUR   SULFUR

  28M BY 100M                        FLOAT-1.30    54.74    1.86    0.16    0.72  15,355         54.74    1.86    0.16    0.72  15,355
  PERCENT OF FLOW   4.4               1.30-1.35    15.42    5.61    0.58    1.10  14,907         70.16    2.68    0.25    0.80  15,257
                                      1.35-1.40     8.09    8.52    0.97    1.44  13,909         78.25    3.29    0.33    0.87  15,117
                                      1.40-1.50     5.09   15.55    1.73    2.29  12,682         83.35    4.04    0.41    0.96  14,968
                                      1.50-1.60     2.41   23.81    2.73    3.19  11,077         85.76    4.59    0.48    1.02  14,859
                                      1.60-1.70     1.31   30.71    3.95    4.53   9,723         87.07    4.98    0.53    1.07  14,782
                                      1.70-1.80     0.86   38.13    5.90    6.47   8,269         87.93    5.31    0.58    1.12  14,718
                                      1.80-SINK    12.07   64.40   29.39   30.84   2,285        100.00   12.44    4.06    4.71  13,217

  100M BY 325M                       FLOAT-1.30    41.17    1.43    0.12    0.66  15,355         41.17    1.43    0.12    0.66  15,355
  PERCENT OF FLOW   4.0               1.30-1.35    22.53    3.21    0.31    0.88  14,907         63.69    2.06    0.19    0.74  15,197
                                      1.35-1.40    13.80    4.86    0.49    1.07  13,909         77.49    2.56    0.25    0.80  14,967
                                      1.40-1.50     5.66   12.16    1.26    1.79  12,682         83.15    3.21    0.32    0.87  14,812
                                      1.50-1.60     2.42   19.47    2.42    2.98  11,077         85.57    3.67    0.37    0.93  14,706
                                      1.60-1.70     1.14   26.63    3.97    4.31   9,723         86.71    3.97    0.42    0.97  14,641
                                      1.70-1.80     0.64   35.16    6.75    7.33   8,269         87.35    4.20    0.47    1.02  14,594
                                      1.80-SINK    12.65   62.19   30.85   32.05   2,027        100.00   11.54    4.31    4.94  13,004

  COMPOSITE                          FLOAT-1.30    28.49    2.45    0.14    0.74  15,355         28.49    2.45    0.14    0.74  15,355
  FLOWRATE           438.6            1.30-1.35    17.85    4.57    0.49    1.09  14,907         46.34    3.26    0.28    0.88  15,182
                                      1.35-1.40     5.69    8.69    0.88    1.41  13,909         52.03    3.86    0.34    0.93  15,043
                                      1.40-1.50     9.55   15.58    1.55    2.11  12,682         61.58    5.67    0.53    1.12  14,677
                                      1.50-1.60     3.38   25.56    2.09    2.57  11,077         64.96    6.71    0.61    1.19  14,490
                                      1.60-1.70     2.08   33.07    3.48    4.00   9,723         67.04    7.53    0.70    1.28  14,342
                                      1.70-1.80     1.21   42.35    5.45    5.95   8,269         68.25    8.15    0.78    1.36  14,234
                                      1.80-SINK    31.75   76.28   27.15   28.75   2,242        100.00   29.78    9.16   10.06  10,427
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                                                                                                   USER HANDBOOK EXAMPLE PAGE 12
                                  SUMMARY OF THE PERFORMANCE CHARACTERISTICS OF UNIT NUMBER  3

                                                         WET UPPER SCREEN
                                                   SIZE OF OPENING = 1.50 INCHES

SIZE, INCHES OR MESH
                                                 6         2       1/2        8M       28M      100M       COMP
                                                BY        BY        BY        BY        BY        BY
                                                 2       1/2        8M       28M      100M      325M
SCREEN ANALYSIS, PERCENT-
   FEED..................................    44.22     22.15     17.57      7.56      4.38      4.04     100.00
   OVERFLOW (COARSE) STREAM..............    84.34     15.49      0.02      0.00      0.00      0.00     100.00
   UNDERFLOW (FINE) STREAM...............     0.00     29.50     36.91     15.88      9.21      8.49     100.00
ASH, PERCENT
   FEED..................................    39.25     27.02     22.75     17.93     12.44     11.54      29.78
   OVERFLOW (COARSE) STREAM..............    39.25     27.02     22.75     17.93     12.44     11.54      37.43
   UNDERFLOW (FINE) STREAM...............     0.00     27.02     22.75     17.93     12.44     11.54      21.35
PYRITIC SULFUR, PERCENT
   FEED..................................    11.06     10.25      7.02      5.42      4.06      4.31       9.16
   OVERFLOW (COARSE) STREAM..............    11.06     10.25      7.02      5.42      4.06      4.31      10.91
   UNDERFLOW (FINE) STREAM...............     0.00     10.25      7.02      5.42      4.06      4.31       7.22
TOTAL SULFUR, PERCENT
   FEED..................................    11.93     11.49      7.80      6.07      4.71      4.94      10.06
   OVERFLOW (COARSE) STREAM..............    11.93     11.49      7.80      6.07      4.71      4.94      11.85
   UNDERFLOW (FINE) STREAM...............     0.00     11.49      7.80      6.07      4.71      4.94       8.09
BTU/LB, MOISTURE FREE
   FEED..................................    8,908    10,768    11,687    12,484    13,217    13,004     10,427
   OVERFLOW (COARSE) STREAM..............    8,908    10,768    11,687    12,484    13,217    13,004      9,185
   UNDERFLOW (FINE) STREAM...............        0    10,768    11,687    12,484    13,217    13,004     11,795
WEIGHT RATIO, UNDERFLOW TO FEED.... PERCENT    0.0      63.3      99.9     100.0     100.0     100.0       47.6
BTU RATIO, UNDERFLOW TO FEED.......     DO     0.0      63.3      99.9     100.0     100.0     100.0       53.8
UNDERSIZE MATERIAL IN OVERFLOW STREAM.  DO     0.0      15.5       0.0       0.0       0.0       0.0       15.5
OVERSIZE MATERIAL IN UNDERFLOW STREAM.  DO     0.0       0.0       0.0       0.0       0.0       0.0        0.0
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                                                                                                USER HANDBOOK EXAMPLE PAGE 13
                                    SPECIFIC GRAVITY ANALYSIS OF FLOWSTREAM NUMBER 5

                            ORIGIN - UNIT NUMBER   3   U       DESTINATION - UNIT NUMBER   5

                                SPECIFIC                DIRECT, PERCENT                            CUMULATIVE, PERCENT
     SIZE FRACTION AND WEIGHT   GFAVITY     WEIGHT    ASH  PYRITIC  TOTAL  BTU/LB       WEIGHT    ASH  PYRITIC  TOTAL  BTU/LB
                                                           SULFUR   SULFUR                                SULFUR   SULFUR

  12 BY 6                       FLOAT-1.30    1.68    2.86   0.19    0.80  15,355         1.68   2.86    0.19    0.80  15,355
  PERCENT OF FLOW   0.1          1.30-1.35    1.25    4.61   0.65    1.32  14,907         2.93   3.61    0.39    1.02  15,164
                                 1.35-1.40    0.40    9.12   1.04    1.64  13,909         3.33   4.26    0.46    1.09  15,014
                                 1.40-1.50    0.70   16.01   1.30    1.82  12,682         4.03   6.31    0.61    1.22  14,609
                                 1.50-1.60    0.32   26.34   1.86    2.33  11,077         4.35   7.79    0.70    1.30  14,347
                                 1.60-1.70    0.19   33.93   3.12    3.69   9,723         4.55   8.90    0.80    1.40  14,152
                                 1.70-1.80    0.10   44.47   5.91    6.45   8,269         4.65   9.67    0.91    1.51  14,025
                                 1.80-SINK   95.35   99.16   0.89    0.94      79       100.00  95.01    0.89    0.97     727

  6 3Y 2                        FLOAT-1.30   22.29    2.83   0.15    0.80  15,355        22.29   2.83    0.15    0.80  15,355
  PERCENT OF FLOW  84.3          1.30-1.35   14.09    4.50   0.64    1.31  14,907        36.38   3.48    0.34    1.00  15,181
                                 1.35-1.40    3.54    8.62   1.13    1.73  13,909        39.91   3.93    0.41    1.06  15,069
                                 1.40-1.50   11.23   15.54   1.74    2.33  12,682        51.14   6.48    0.70    1.34  14,545
                                 1.50-1.60    2.91   25.78   2.24    2.77  11,077        54.06   7.52    0.78    1.42  14,358
                                 1.60-1.70    2.07   32.75   3.63    4.24   9,723        56.13   8.45    0.89    1.52  14,187
                                 1.70-1.80    0.97   42.99   5.76    6.40   8,269        57.10   9.04    0.97    1.60  14,086
                                 1.80-SINK   42.90   79.45  24.47   25.68   2,016       100.00  39.25   11.06   11.93   8,908

  2 BY 1/2                      FLOAT-1.30   25.18    2.62   0.15    0.78  15,355        25.18   2.62    0.15    0.78  15,355
  PERCENT OF FLOW  15.5          1.30-1.35   20.15    4.64   0.55    1.12  14,907        45.33   3.52    0.33    0.93  15,156
                                 1.35-1.40    6.51    9.35   1.00    1.51  13,909        51.84   4.25    0.42    1.01  14,999
                                 1.40-1.50    9.97   15.92   1.52    2.08  12,682        61.81   6.14    0.59    1.18  14,625
                                 1.50-1.60    4.64   26.02   2.06    2.52  11,077        66.45   7.52    0.70    1.27  14,378
                                 1.60-1.70    2.55   33.81   3.46    3.98   9,723        69.00   8.49    0.80    1.37  14,206
                                 1.70-1.60    1.57   43.01   5.69    6.21   8,269        70.57   9.26    0.91    1.48  14,074
                                 1.80-SINK   29.43   69.61  32.65   35.48   2,841       100.00  27.02   10.25   11.49  10,768

  COMPOSITE                     FLOAT-1.30   22.71    2.79   0.15    0.80  15,355        22.71   2.79    0.15    0.80  15,355
  FLOWRATE           229.9       1.30-1.35   15.01    4.53   0.62    1.27  14,907        37.72   3.48    0.34    0.98  15,177
                                 1.35-1.40    3.99    8.81   1.10    1.68  13,909        41.72   3.99    0.41    1.05  15,055
                                 1.40-1.50   11.02   15.59   1.71    2.29  12,682        52.74   6.42    0.68    1.31  14,559
                                 1.50-1.60    3.18   25.83   2.20    2.71  11,077        55.91   7.52    0.77    1.39  14,362
                                 1.60-1.70    2.14   32.95   3.60    4.20   9,723        58.06   8.46    0.87    1.49  14,190
                                 1.70-1.80    1.06   43.00   5.75    6.35   8,269        59.12   9.08    0.96    1.58  14,084
                                 1.80-SINK   40.88   78.42  25.31   26.69   2,101       100.00  37.43   10.91   11.85   9,185
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                         SPECIFIC GRAVITY ANALYSIS OF FLOWSTREAM NUMBER 6

                    ORIGIN - UNIT NUMBER   3   L         DESTINATION - UNIT NUMBER   4

    SIZE FRACTION AND WEIGHT     SPECIFIC             DIRECT, PERCENT                                    CUMULATIVE, PERCENT
                                 GRAVITY     WEIGHT    ASH  PYRITIC   TOTAL   BTU/LB        WEIGHT    ASH  PYRITIC   TOTAL   BTU/LB
                                                            SULFUR   SULFUR                                SULFUR   SULFUR
 2 BY 1/2
 PERCENT OF FLOW  29.5          FLOAT-1.30    25.18    2.62    0.15    0.78   15,355         25.18    2.62    0.15    0.78   15,355
                                 1.30-1.35    20.15    4.64    0.55    1.12   14,907         45.33    3.52    0.33    0.93   15,156
                                 1.35-1.40     6.51    9.35    1.00    1.51   13,909         51.84    4.25    0.42    1.01   14,999
                                 1.40-1.50     3.97   15.92    1.52    2.08   12,682         61.81    6.14    0.59    1.18   14,625
                                 1.50-1.60     4.64   26.02    2.06    2.52   11,077         66.45    7.52    0.70    1.27   14,378
                                 1.60-1.70     2.55   33.81    3.46    3.98    9,723         69.00    8.49    0.80    1.37   14,206
                                 1.70-1.80     1.57   43.01    5.69    6.21    8,269         70.57    9.26    0.91    1.48   14,074
                                 1.80-SINK    29.43   69.61   32.65   35.48    2,841        100.00   27.02   10.25   11.49   10,758
 1/2 BY 8M
 PERCENT OF FLOW  36.9          FLOAT-1.30    32.31    2.47    0.10    0.67   15,355         32.31    2.47    0.10    0.67   15,355
                                 1.30-1.35    22.76    4.75    0.23    0.81   14,907         55.07    3.41    0.15    0.73   15,170
                                 1.35-1.40     7.34    9.59    0.59    1.07   13,909         62.40    4.14    0.20    0.77   15,022
                                 1.40-1.50     8.26   15.75    1.00    1.53   12,682         70.66    5.50    0.29    0.86   14,748
                                 1.50-1.60     3.68   25.82    1.69    2.10   11,077         74.34    6.50    0.36    0.92   14,567
                                 1.60-1.70     2.09   33.75    3.03    3.36    9,723         76.43    7.25    0.44    0.99   14,434
                                 1.70-1.80     1.55   41.92    4.39    4.66    8,269         77.97    7.93    0.52    1.06   14,312
                                 1.80-SINK    22.03   75.21   30.04   31.67    2,397        100.00   22.75    7.02    7.80   11,687
 8M BY 28M
 PERCENT OF FLOW  15.9          FLOAT-1.30    43.91    1.95    0.18    0.68   15,355         43.91    1.95    0.18    0.68   15,355
                                 1.30-1.35    20.75    4.44    0.41    0.94   14,907         64.67    2.75    0.26    0.77   15,211
                                 1.35-1.40     6.35    9.05    0.88    1.38   13,909         71.02    3.31    0.31    0.82   15,095
                                 1.40-1.50     6.21   15.56    1.34    1.87   12,682         77.23    4.30    0.39    0.91   14,901
                                 1.50-1.60     2.87   25.02    2.03    2.48   11,077         80.11    5.04    0.45    0.96   14,764
                                 1.60-1.70     1.72   33.46    3.33    3.85    9,723         81.83    5.64    0.51    1.02   14,657
                                 1.70-1.80     1.29   41.88    5.66    6.05    8,269         83.11    6.20    0.59    1.10   14,559
                                 1.80-SINK    16.89   75.68   29.19   30.54    2,272        100.00   17.93    5.42    6.07   12,484
 28M BY 100M
 PERCENT OF FLOW   9.2          FLOAT-1.30    54.74    1.86    0.16    0.72   15,355         54.74    1.86    0.16    0.72   15,355
                                 1.30-1.35    15.42    5.61    0.58    1.10   14,907         70.16    2.68    0.25    0.80   15,257
                                 1.35-1.40     8.09    8.52    0.97    1.44   13,909         78.25    3.29    0.33    0.87   15,117
                                 1.40-1.50     5.09   15.55    1.73    2.29   12,682         83.35    4.04    0.41    0.96   14,968
                                 1.50-1.60     2.41   23.81    2.73    3.19   11,077         85.76    4.59    0.48    1.02   14,859
                                 1.60-1.70     1.31   30.71    3.95    4.53    9,723         87.07    4.98    0.53    1.07   14,782
                                 1.70-1.80     0.86   38.13    5.90    6.47    8,269         87.93    5.31    0.58    1.12   14,718
                                 1.80-SINK    12.07   64.40   29.39   30.84    2,285        100.00   12.44    4.06    4.71   13,217
 100M BY 325M
 PERCENT OF FLOW   8.5          FLOAT-1.30    41.17    1.43    0.12    0.66   15,355         41.17    1.43    0.12    0.66   15,355
                                 1.30-1.35    22.53    3.21    0.33    0.88   14,907         63.69    2.06    0.19    0.74   15,197
                                 1.35-1.40    13.80    4.86    0.49    1.07   13,909         77.49    2.56    0.25    0.80   14,967
                                 1.40-1.50     5.66   12.16    1.26    1.79   12,682         83.15    3.21    0.32    0.87   14,812
                                 1.50-1.60     2.42   19.47    2.42    2.98   11,077         85.57    3.67    0.37    0.93   14,706
                                 1.60-1.70     1.14   26.63    3.97    4.31    9,723         86.71    3.97    0.42    0.97   14,641
                                 1.70-1.80     0.64   35.16    6.75    7.33    8,269         87.35    4.20    0.47    1.02   14,594
                                 1.80-SINK    12.65   62.19   30.85   32.05    2,027        100.00   11.54    4.31    4.94   13,004
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                                                                                                              USER HANDBOOK EXAMPLE PAGE 15

                                               SPECIFIC GRAVITY ANALYSIS OF FLOWSTREAM NUMBER 6 (CONTINUED)

                                         ORIGIN - UNIT NUMBER   3   L        DESTINATION - UNIT NUMBER   4

                                             SPECIFIC             DIRECT, PERCENT                                     CUMULATIVE, PERCENT
      SIZE FRACTION AND WEIGHT               GRAVITY     WEIGHT    ASH  PYRITIC   TOTAL   BTU/LB        WEIGHT    ASH  PYRITIC   TOTAL   BTU/LB
                                                                        SULFUR   SULFUR                                 SULFUR  SULFUR

COMPOSITE                                   FLOAT-1.30    34.87    2.21    0.14    0.70  15,355          34.87    2.21    0.14    0.70  15,355
FLOWRATE             208.6                   1.30-1.35    20.97    4.59    0.38    0.95  14,907          55.84    3.10    0.23    0.80  15,187
                                             1.35-1.40     7.56    8.62    0.75    1.26  13,909          63.40    3.76    0.29    0.85  15,034
                                             1.40-1.50     7.92   15.56    1.29    1.84  12,682          71.32    5.07    0.40    0.96  14,773
                                             1.50-1.60     3.61   25.31    1.98    2.43  11,077          74.93    6.04    0.48    1.03  14,595
                                             1.60-1.70     2.02   33.21    3.33    3.77   9,723          76.95    6.76    0.55    1.10  14,467
                                             1.70-1.80     1.37   41.80    5.20    5.60   8,269          78.32    7.37    0.63    1.18  14,359
                                             1.80-SINK    21.68   71.83   30.99   33.03   2,535         100.00   21.35    7.22    8.09  11,795
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                    SUMMARY OF THE PERFORMANCE CHARACTERISTICS OF UNIT NUMBER  4

                                             WET LOWER SCREEN
                                         SIZE OF OPENING = 0.50 INCHES

SIZE, INCHES OR MESH                             2        1/2        8M        28M       100M      COMP
                                                BY         BY        BY         BY         BY
                                               1/2         8M       28M       100M       325M

SCREEN ANALYSIS, PERCENT-
   FEED.................................... 29.50      36.91     15.88       9.21       8.49    100.00
   OVERFLOW (COARSE) STREAM................ 92.73       7.09      0.12       0.04       0.03    100.00
   UNDERFLOW (FINE) STREAM.................  0.00      50.82     23.24      13.50      12.44    100.00

ASH, PERCENT
   FEED.................................... 27.02      22.75     17.93      12.44      11.54     21.35
   OVERFLOW (COARSE) STREAM................ 27.02      22.75     17.93      12.44      11.54     26.70
   UNDERFLOW (FINE) STREAM.................  0.00      22.75     17.93      12.44      11.54     18.85

PYRITIC SULFUR, PERCENT
   FEED.................................... 10.25       7.02      5.42       4.06       4.31      7.22
   OVERFLOW (COARSE) STREAM................ 10.25       7.02      5.42       4.06       4.31     10.01
   UNDERFLOW (FINE) STREAM.................  0.00       7.02      5.42       4.06       4.31      5.91

TOTAL SULFUR, PERCENT
   FEED.................................... 11.49       7.80      6.07       4.71       4.94      8.09
   OVERFLOW (COARSE) STREAM................ 11.49       7.80      6.07       4.71       4.94     11.22
   UNDERFLOW (FINE) STREAM.................  0.00       7.80      6.07       4.71       4.94      6.63

BTU/LB, MOISTURE FREE
   FEED....................................10,768     11,687    12,484     13,217     13,004    11,795
   OVERFLOW (COARSE) STREAM................10,768     11,687    12,484     13,217     13,004    10,836
   UNDERFLOW (FINE) STREAM.................     0     11,687    12,484     13,217     13,004    12,243

WEIGHT RATIO, UNDERFLOW TO FEED.... PERCENT   0.0       93.9      99.8       99.9       99.9      68.2
BTU RATIO, UNDERFLOW TO FEED.......     DO    0.0       93.9      99.8       99.9       99.9      70.8
UNDERSIZE MATERIAL IN OVERFLOW STREAM.  DO    0.0        7.1       0.1        0.0        0.0       7.3
OVERSIZE MATERIAL IN UNDERFLOW STREAM.  DO    0.0        0.0       0.0        0.0        0.0       0.0
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                                                                                                       USER HANDBOOK EXAMPLE PAGE 17
                                           SPECIFIC GRAVITY ANALYSIS OF FLOWSTREAM NUMBER 7

                                 ORIGIN - UNIT NUMBER   4   U       DESTINATION - UNIT NUMBER   5

     SIZE FRACTION AND WEIGHT         SPECIFIC               DIRECT, PERCENT                                      CUMULATIVE, PERCENT
                                      GRAVITY     WEIGHT    ASH  PYRITIC  TOTAL   BTU/LB        WEIGHT    ASH  PYRITIC   TOTAL   BTU/LB
                                                                 SULFUR   SULFUR                                SULFUR   SULFUR
 2 BY 1/2
 PERCENT OF FLOW  92.7               FLOAT-1.30   25.18    2.62    0.15     0.78  15,355         25.18    2.62    0.15     0.78  15,355
                                      1.30-1.35   20.15    4.64    0.55     1.12  14,907         45.33    3.52    0.33     0.93  15,156
                                      1.35-1.40    6.51    9.35    1.00     1.51  13,909         51.84    4.25    0.42     1.01  14,999
                                      1.40-1.50    9.97   15.92    1.52     2.08  12,682         61.81    6.14    0.59     1.18  14,625
                                      1.50-1.60    4.64   26.02    2.06     2.52  11,077         66.45    7.52    0.70     1.27  14,378
                                      1.60-1.70    2.55   33.81    3.46     3.98   9,723         69.00    8.49    0.80     1.37  14,206
                                      1.70-1.80    1.57   43.01    5.69     6.21   8,269         70.57    9.26    0.91     1.48  14,074
                                      1.80-SINK   29.43   69.61   32.65    35.48   2,841        100.00   27.02   10.25    11.49  10,768
 1/2 BY 8M
 PERCENT OF FLOW   7.1               FLOAT-1.30   32.31    2.47    0.10     0.67  15,355         32.31    2.47    0.10     0.67  15,355
                                      1.30-1.35   22.76    4.75    0.23     0.81  14,907         55.07    3.41    0.15     0.73  15,170
                                      1.35-1.40    7.34    9.59    0.59     1.07  13,909         62.40    4.14    0.20     0.77  15,022
                                      1.40-1.50    8.26   15.75    1.00     1.53  12,682         70.66    5.50    0.29     0.86  14,748
                                      1.50-1.60    3.68   25.92    1.69     2.10  11,077         74.34    6.50    0.36     0.92  14,567
                                      1.60-1.70    2.09   33.75    3.03     3.36   9,723         76.43    7.25    0.44     0.99  14,434
                                      1.70-1.80    1.55   41.92    4.39     4.66   8,269         77.97    7.93    0.52     1.06  14,312
                                      1.80-SINK   22.03   75.21   30.04    31.67   2,397        100.00   22.75    7.02     7.80  11,687
 8M BY 28M
 PERCENT OF FLOW   0.1               FLOAT-1.30   43.91    1.95    0.18     0.68  15,355         43.91    1.95    0.18     0.68  15,355
                                      1.30-1.35   20.75    4.44    0.41     0.94  14,907         64.67    2.75    0.26     0.77  15,211
                                      1.35-1.40    6.35    9.05    0.88     1.38  13,909         71.02    3.31    0.31     0.82  15,095
                                      1.40-1.50    6.21   15.56    1.34     1.87  12,682         77.23    4.30    0.39     0.91  14,901
                                      1.50-1.60    2.87   25.02    2.03     2.48  11,077         80.11    5.04    0.45     0.96  14,764
                                      1.60-1.70    1.72   33.46    3.33     3.85   9,723         81.83    5.64    0.51     1.02  14,657
                                      1.70-1.80    1.29   41.88    5.66     6.05   8,269         83.11    6.20    0.59     1.10  14,559
                                      1.80-SINK   16.89   75.68   29.19    30.54   2,272        100.00   17.93    5.42     6.07  12,484
 COMPOSITE
 FLOWRATE            66.4            FLOAT-1.30   25.72    2.61    0.15     0.77  15,355         25.72    2.61    0.15     0.77  15,355
                                      1.30-1.35   20.34    4.65    0.53     1.10  14,907         46.05    3.51    0.32     0.92  15,157
                                      1.35-1.40    6.58    9.37    0.97     1.48  13,909         52.63    4.24    0.40     0.99  15,001
                                      1.40-1.50    9.84   15.91    1.49     2.05  12,682         62.47    6.08    0.57     1.15  14,636
                                      1.50-1.60    4.56   26.00    2.04     2.50  11,077         67.04    7.44    0.67     1.25  14,394
                                      1.60-1.70    2.52   33.81    3.43     3.95   9,723         69.55    8.39    0.77     1.34  14,224
                                      1.70-1.80    1.56   42.93    5.60     6.10   8,269         71.12    9.15    0.88     1.45  14,093
                                      1.80-SINK   28.88   69.92   32.50    35.27   2,817        100.00   26.70   10.01    11.22  10,836
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                          SPECIFIC GRAVITY ANALYSIS OF FLOWSTREAM NUMBER 8

                    ORIGIN - UNIT NUMBER   4  L      DESTINATION - UNIT NUMBER   9

                                  SPECIFIC           DIRECT, PERCENT                                   CUMULATIVE, PERCENT
  SIZE FRACTION AND WEIGHT        GRAVITY    WEIGHT    ASH  PYRITIC  TOTAL   BTU/LB      WEIGHT    ASH  PYRITIC  TOTAL   BTU/LB
                                                                SULFUR   SULFUR                               SULFUR   SULFUR

1/2 BY 8M                       FLOAT-1.30   32.31    2.47    0.10    0.67  15,355      32.31    2.47    0.10    0.67  15,355
PERCENT OF FLOW  50.8            1.30-1.35   22.76    4.75    0.23    0.81  14,907      55.07    3.41    0.15    0.73  15,170
                                 1.35-1.40    7.34    9.59    0.59    1.07  13,909      62.40    4.14    0.20    0.77  15,022
                                 1.40-1.50    8.26   15.75    1.00    1.53  12,682      70.66    5.50    0.29    0.86  14,748
                                 1.50-1.60    3.68   25.82    1.69    2.10  11,077      74.34    6.50    0.36    0.92  14,567
                                 1.60-1.70    2.09   33.75    3.03    3.36   9,723      76.43    7.25    0.44    0.99  14,434
                                 1.70-1.80    1.55   41.92    4.39    4.66   8,269      77.97    7.93    0.52    1.06  14,312
                                 1.80-SINK   22.03   75.21   30.04   31.67   2,397     100.00   22.75    7.02    7.80  11,687

8M BY 28M                       FLOAT-1.30   43.91    1.95    0.18    0.68  15,355      43.91    1.95    0.18    0.68  15,355
PERCENT OF FLOW  23.2            1.30-1.35   20.75    4.44    0.41    0.94  14,907      64.67    2.75    0.26    0.77  15,211
                                 1.35-1.40    6.35    9.05    0.88    1.38  13,909      71.02    3.31    0.31    0.82  15,095
                                 1.40-1.50    6.21   15.56    1.34    1.87  12,682      77.23    4.30    0.39    0.91  14,901
                                 1.50-1.60    2.87   25.02    2.03    2.48  11,077      80.11    5.04    0.45    0.96  14,764
                                 1.60-1.70    1.72   33.46    3.33    3.85   9,723      81.83    5.64    0.51    1.02  14,657
                                 1.70-1.80    1.29   41.88    5.66    6.05   8,269      83.11    6.20    0.59    1.10  14,559
                                 1.80-SINK   16.89   75.68   29.19   30.54   2,272     100.00   17.93    5.42    6.07  12,484

28M BY 100M                     FLOAT-1.30   54.74    1.86    0.16    0.72  15,355      54.74    1.86    0.16    0.72  15,355
PERCENT OF FLOW  13.5            1.30-1.35   15.42    5.61    0.58    1.10  14,907      70.16    2.68    0.25    0.80  15,257
                                 1.35-1.40    8.09    8.52    0.97    1.44  13,909      78.25    3.29    0.33    0.87  15,117
                                 1.40-1.50    5.09   15.55    1.73    2.29  12,682      83.35    4.04    0.41    0.96  14,968
                                 1.50-1.60    2.41   23.91    2.73    3.19  11,077      85.76    4.59    0.48    1.02  14,859
                                 1.60-1.70    1.31   33.71    3.95    4.53   9,723      87.07    4.98    0.53    1.07  14,782
                                 1.70-1.80    0.86   38.13    5.90    6.47   8,269      87.93    5.31    0.58    1.12  14,718
                                 1.80-SINK   12.07   64.40   29.39   30.84   2,285     100.00   12.44    4.06    4.71  13,217

100M BY 325M                    FLOAT-1.30   41.17    1.43    0.12    0.66  15,355      41.17    1.43    0.12    0.66  15,355
PERCENT OF FLOW  12.4            1.30-1.35   22.53    3.21    0.33    0.88  14,907      63.69    2.06    0.19    0.74  15,197
                                 1.35-1.40   13.80    4.86    0.49    1.07  13,909      77.49    2.56    0.25    0.80  14,967
                                 1.40-1.50    5.65   12.16    1.26    1.79  12,682      83.15    3.21    0.32    0.87  14,812
                                 1.50-1.60    2.42   19.47    2.42    2.98  11,077      85.57    3.67    0.37    0.93  14,706
                                 1.60-1.70    1.14   26.63    3.97    4.31   9,723      86.71    3.97    0.42    0.97  14,641
                                 1.70-1.80    0.64   35.16    6.75    7.33   8,269      87.35    4.20    0.47    1.02  14,594
                                 1.80-SINK   12.65   62.19   30.85   32.05   2,027     100.00   11.54    4.31    4.94  13,004

COMPOSITE                       FLOAT-1.30   39.14    2.08    0.13    0.68  15,355      39.14    2.08    0.13    0.68  15,355
FLOWRATE          142.3          1.30-1.35   21.27    4.56    0.32    0.88  14,907      60.41    2.96    0.20    0.75  15,197
                                 1.35-1.40    8.01    8.33    0.67    1.18  13,909      68.42    3.59    0.25    0.80  15,046
                                 1.40-1.50    7.03   15.33    1.16    1.70  12,682      75.45    4.68    0.34    0.89  14,826
                                 1.50-1.60    3.15   24.84    1.94    2.38  11,077      78.62    5.49    0.40    0.95  14,675
                                 1.60-1.70    1.78   32.92    3.26    3.66   9,723      80.40    6.10    0.47    1.01  14,565
                                 1.70-1.80    1.28   41.15    4.97    5.31   8,269      81.68    6.65    0.54    1.07  14,467
                                 1.80-SINK   18.32   73.23   29.87   31.39   2,328     100.00   18.85    5.91    6.63  12,243
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                                                                                    USER HANDBOOK EXAMPLE PAGE 19
                                  SUMMARY OF THE PERFORMANCE CHARACTERISTICS OF UNIT NUMBER  5

                                                      STREAM BLENDER

SIZE, INCHES OR MESH
                                                12         6         2       1/2        8M       28M      100M      COMP
                                                BY        BY        BY        BY        BY        BY        BY
                                                 6         2       1/2        8M       28M      100M      325M

SCREEN ANALYSIS, PERCENT-
   PRODUCT....................................  0.09     65.45     32.79      1.61      0.03      0.01      0.01    100.00
   FEED 1.....................................  0.12     84.34     15.49      0.02      0.00      0.00      0.00    100.00
   FEED 2.....................................  0.00      0.00     92.73      7.09      0.12      0.04      0.03    100.00

ASH, PERCENT
   PRODUCT.................................... 95.01     39.25     27.02     22.75     17.93     12.44     11.54     35.02
   FEED 1..................................... 95.01     39.25     27.02     22.75     17.93     12.44     11.54     37.43
   FEED 2.....................................  0.00      0.00     27.02     22.75     17.93     12.44     11.54     26.70

PYRITIC SULFUR, PERCENT
   PRODUCT....................................  0.89     11.06     10.25      7.02      5.42      4.06      4.31     10.71
   FEED 1.....................................  0.89     11.06     10.25      7.02      5.42      4.06      4.31     10.91
   FEED 2.....................................  0.00      0.00     10.25      7.02      5.42      4.06      4.31     10.01

TOTAL SULFUR, PERCENT
   PRODUCT....................................  0.97     11.93     11.49      7.80      6.07      4.71      4.94     11.71
   FEED 1.....................................  0.97     11.93     11.49      7.80      6.07      4.71      4.94     11.85
   FEED 2.....................................  0.00      0.00     11.49      7.80      6.07      4.71      4.94     11.22

BTU/LB, MOISTURE FREE
   PRODUCT....................................   727     8,908    10,768    11,687    12,484    13,217    13,004     9,555
   FEED 1.....................................   727     8,908    10,768    11,687    12,484    13,217    13,004     9,185
   FEED 2.....................................     0         0    10,768    11,687    12,484    13,217    13,004    10,836
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                           SPECIFIC GRAVITY ANALYSIS OF FLOWSTREAM NUMBER 9

                      ORIGIN - UNIT NUMBER   5   U       DESTINATION - UNIT NUMBER   6

                                 SPECIFIC           DIRECT, PERCENT                                  CUMULATIVE, PERCENT
  SIZE FRACTION AND WEIGHT       GRAVITY    WEIGHT    ASH  PYRITIC   TOTAL   BTU/LB     WEIGHT    ASH  PYRITIC   TOTAL   BTU/LB
                                                           SULFUR   SULFUR                              SULFUR   SULFUR
12 BY 6                        FLOAT-1.30    1.68    2.86    0.19    0.80  15,355       1.68    2.86    0.19    0.80  15,355
PERCENT OF FLOW   0.1           1.30-1.35    1.25    4.61    0.65    1.32  14,907       2.93    3.61    0.39    1.02  15,164
                                1.35-1.40    0.40    9.12    1.04    1.64  13,909       3.33    4.26    0.46    1.09  15,014
                                1.40-1.50    0.70   16.01    1.30    1.82  12,682       4.03    6.31    0.61    1.22  14,609
                                1.50-1.60    0.32   26.34    1.86    2.33  11,077       4.35    7.79    0.70    1.30  14,347
                                1.60-1.70    0.19   33.93    3.12    3.69   9,723       4.55    8.90    0.80    1.40  14,152
                                1.70-1.80    0.10   44.47    5.91    6.45   8,269       4.65    9.67    0.91    1.51  14,025
                                1.80-SINK   95.35   99.16    0.89    0.94      79     100.00   95.01    0.89    0.97     727
6 BY 2                         FLOAT-1.30   22.29    2.83    0.15    0.80  15,355      22.29    2.83    0.15    0.80  15,355
PERCENT OF FLOW  65.5           1.30-1.35   14.09    4.50    0.64    1.31  14,907      36.38    3.48    0.34    1.00  15,181
                                1.35-1.40    3.54    8.62    1.13    1.73  13,909      39.91    3.93    0.41    1.06  15,069
                                1.40-1.50   11.23   15.54    1.74    2.33  12,682      51.14    6.48    0.70    1.34  14,545
                                1.50-1.60    2.91   25.78    2.24    2.77  11,077      54.06    7.52    0.78    1.42  14,358
                                1.60-1.70    2.07   32.75    3.63    4.24   9,723      56.13    8.45    0.89    1.52  14,187
                                1.70-1.80    0.97   42.99    5.76    6.40   8,269      57.10    9.04    0.97    1.60  14,086
                                1.80-SINK   42.90   79.45   24.47   25.68   2,016     100.00   39.25   11.06   11.93   8,908
2 BY 1/2                       FLOAT-1.30   25.18    2.62    0.15    0.78  15,355      25.18    2.62    0.15    0.78  15,355
PERCENT OF FLOW  32.8           1.30-1.35   20.15    4.64    0.55    1.12  14,907      45.33    3.52    0.33    0.93  15,156
                                1.35-1.40    6.51    9.35    1.00    1.51  13,909      51.84    4.25    0.42    1.01  14,999
                                1.40-1.50    9.97   15.92    1.52    2.08  12,682      61.81    6.14    0.59    1.18  14,625
                                1.50-1.60    4.64   26.02    2.06    2.52  11,077      66.45    7.52    0.70    1.27  14,378
                                1.60-1.70    2.55   33.81    3.46    3.98   9,723      69.00    8.49    0.80    1.37  14,206
                                1.70-1.80    1.57   43.01    5.69    6.21   8,269      70.57    9.26    0.91    1.48  14,074
                                1.80-SINK   29.43   69.61   32.65   35.48   2,841     100.00   27.02   10.25   11.49  10,768
1/2 BY 8M                      FLOAT-1.30   32.31    2.47    0.10    0.67  15,355      32.31    2.47    0.10    0.67  15,355
PERCENT OF FLOW   1.6           1.30-1.35   22.76    4.75    0.23    0.81  14,907      55.07    3.41    0.15    0.73  15,170
                                1.35-1.40    7.34    9.59    0.59    1.07  13,909      62.40    4.14    0.20    0.77  15,022
                                1.40-1.50    8.26   15.75    1.00    1.53  12,682      70.66    5.50    0.29    0.86  14,748
                                1.50-1.60    3.68   25.82    1.69    2.10  11,077      74.34    6.50    0.36    0.92  14,567
                                1.60-1.70    2.09   33.75    3.03    3.36   9,723      76.43    7.25    0.44    0.99  14,434
                                1.70-1.80    1.55   41.92    4.39    4.66   8,269      77.97    7.93    0.52    1.06  14,312
                                1.80-SINK   22.03   75.21   30.04   31.67   2,397     100.00   22.75    7.02    7.80  11,687
COMPOSITE                      FLOAT-1.30   23.38    2.75    0.15    0.79  15,355      23.38    2.75    0.15    0.79  15,355
FLOWRATE         296.3          1.30-1.35   16.20    4.57    0.59    1.22  14,907      39.59    3.49    0.33    0.97  15,172
                                1.35-1.40    4.57    8.99    1.06    1.61  13,909      44.16    4.06    0.41    1.03  15,041
                                1.40-1.50   10.76   15.66    1.66    2.24  12,682      54.92    6.33    0.65    1.27  14,579
                                1.50-1.60    3.49   25.88    2.16    2.65  11,077      58.40    7.50    0.74    1.35  14,370
                                1.60-1.70    2.23   33.16    3.56    4.13   9,723      60.63    8.44    0.85    1.45  14,199
                                1.70-1.80    1.17   42.98    5.70    6.28   8,269      61.80    9.10    0.94    1.55  14,087
                                1.80-SINK   38.20   76.98   26.53   28.15   2,222     100.00   35.02   10.71   11.71   9,555
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                                          SUMMARY OF THE PERFORMANCE CHARACTERISTICS OF UNIT NUMBER  6

                                                                TWO-STAGE BAUM JIG
                                                        SPECIFIC GRAVITY OF SEPARATION =1.62

SIZE, INCHES OR MESH                          12         6         2       1/2        8M       28M      100M      COMP
                                              BY        BY        BY        BY        BY        BY        BY
                                               6         2       1/2        8M       28M      100M      325M

SCREEN ANALYSIS, PERCENT-
    FEED.................................   0.09     65.45     32.79      1.61      0.03      0.01      0.01    100.00
    CLEAN COAL...........................   0.91     59.06     38.65      2.21      0.04      0.01      0.01    100.00
    REFUSE...............................   0.21     75.36     23.90      0.48      0.00      0.00      0.00    100.00
    MIDDLINGS............................   0.16     70.31     27.95      1.50      0.03      0.00      0.00    100.00

ASH, PERCENT
    FEED.................................  95.01     39.25     27.02     22.75     17.93     12.44     11.54     35.02
    CLEAN COAL...........................   6.59      6.65      8.01      9.53      9.35      8.45      7.49      7.24
    REFUSE...............................  98.89     74.98     65.67     72.01     45.85     50.40     48.13     72.80
    MIDDLINGS............................  98.25     67.93     61.66     64.91     68.57     60.40     57.79     66.19

PYRITIC SULFUR, PERCENT
    FEED.................................   0.89     11.06     10.25      7.02      5.42      4.06      4.31     10.71
    CLEAN COAL...........................   0.62      0.71      0.96      1.50      2.05      2.17      2.23      0.82
    REFUSE...............................   0.89     22.63     29.54     28.13     16.07     21.69     22.90     24.25
    MIDDLINGS............................   0.91     19.70     26.52     24.26     25.35     26.81     28.07     21.64

TOTAL SULFUR, PERCENT
    FEED.................................   0.97     11.93     11.49      7.80      6.07      4.71      4.94     11.71
    CLEAN COAL...........................   1.24      1.34      1.56      2.09      2.60      2.76      2.82      1.44
    REFUSE...............................   0.95     23.78     32.12     29.67     17.02     22.89     23.92     25.74
    MIDDLINGS............................   0.97     20.77     28.86     25.64     26.57     28.17     29.21     23.06

BTU/LB, MOISTURE FREE
    FEED.................................    727     8,908    10,768    11,687    12,484    13,217    13,004     9,555
    CLEAN COAL...........................14,565    14,522    14,290    14,033    14,004    14,055    13,883    14,421
    REFUSE...............................    120     2,765     3,600     2,961     7,540     5,271     5,080     2,958
    MIDDLINGS............................    216     3,945     4,365     4,207     3,517     3,150     2,968     4,059
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                                                                                                  USER HANDBOOK EXAMPLE PAGE 22
                                    SUMMARY OF THE PERFORMANCE CHARACTERISTICS OF UNIT NUMBER  6 (CONTINUED)

                                                         TWO-STAGE BAUM JIG
                                                   SPECIFIC GRAVITY OF SEPARATION =1.62

SIZE, INCHES OR MESH                                     12         6         2       1/2        8M       28M      100M      COMP
                                                         BY        BY        BY        BY        BY        BY        BY
                                                          6         2       1/2        8M       28M      100M      325M

ACTUAL RECOVERY..................... PERCENT            4.0      50.6      66.1      77.2      85.1      92.1      91.8      56.1
THEORETICAL RECOVERY................    DO              4.1      51.7      67.8      80.3      87.6      93.2      93.0      57.7
RECOVERY EFFICIENCY.................    DO             98.0      98.0      97.5      96.1      97.1      98.8      98.7      97.2
BTU RECOVERY........................    DO             80.5      82.5      87.8      92.7      95.4      98.0      98.0      84.7
ASH ERROR...........................    DO              0.3       0.3       0.6       1.9       1.8       0.6       0.7       0.6
FLOAT IN REFUSE.......... PERCENT OF PRODUCT            0.1       3.2       4.1       5.3      52.6      55.9      55.4       3.3
SINK IN CLEAN COAL......          DO                    2.3       1.7       2.5       4.3       4.7       3.4       3.6       2.8
TOTAL MISPLACED MATERIAL... PERCENT OF FEED             0.2       1.9       2.5       3.8       4.6       3.6       3.8       2.5
NEAR GRAVITY 0.1 MATERIAL..       DO                    0.9      11.3       7.1       3.8       4.1       3.0       3.2      10.0
SPECIFIC GRAVITY OF SEPARATION..............           1.52      1.53      1.60      1.73      1.88      2.11      2.11      1.55
PROBABLE ERROR, SPECIFIC GRAVITY............         -0.099    -0.034     0.024     0.231     0.261     0.305     0.305     0.048
IMPERFECTION................................         -0.065    -0.023     0.015     0.134     0.139     0.144     0.144     0.031
ERROR AREA..................................             29        32        64       138       181       186       186        49
DISTRIBUTION, PERCENT TO WASHED COAL
  (SPECIFIC GRAVITY FRACTION)-
    FLOAT-1.30..............................          100.0     100.0     100.0      99.4      99.7      99.8      99.8     100.0
    1.30-1.35...............................          100.0     100.0      99.9      98.9      98.9      99.5      99.5      99.9
    1.35-1.40...............................           99.7      99.8      99.5      97.6      97.3      98.8      98.8      99.6
    1.40-1.50...............................           81.8      84.5      96.1      93.5      92.2      97.2      97.2      88.1
    1.50-1.60...............................           35.9      38.4      66.7      79.2      82.9      93.1      93.1      51.5
    1.60-1.70...............................            1.5       4.2      36.7      61.9      71.7      87.0      87.0      17.3
    1.70-1.80...............................            0.0       1.4      14.3      46.8      59.8      79.5      79.5       8.1
    SINK-1.80...............................            0.0       0.0       1.7      12.7      26.7      42.6      42.6       0.6
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                              SPECIFIC GRAVITY ANALYSIS OF FLOWSTREAM NUMBER 10

                     ORIGIN - UNIT NUMBER   6   C        DESTINATION - UNIT NUMBER  17

                                      SPECIFIC            DIRECT, PERCENT                                       CUMULATIVE, PERCENT
     SIZE FRACTION AND WEIGHT         GRAVITY     WEIGHT     ASH  PYRITIC   TOTAL   BTU/LB       WEIGHT     ASH  PYRITIC   TOTAL  BTU/LB
                                                                  SULFUR  SULFUR                                  SULFUR  SULFUR

   6 BY 2                            FLOAT-1.30    44.04    2.83     0.15    0.80   15,355        44.04    2.83     0.15    0.80  15,355
   PERCENT OF FLOW  59.1              1.30-1.35    27.84    4.50     0.64    1.31   14,907        71.87    3.48     0.34    1.00  15,181
                                      1.35-1.40     6.97    8.62     1.13    1.73   13,909        78.84    3.93     0.41    1.06  15,069
                                      1.40-1.50    18.75   15.54     1.74    2.33   12,682        97.59    6.16     0.66    1.30  14,610
                                      1.50-1.60     2.21   25.78     2.24    2.77   11,077        99.80    6.60     0.70    1.34  14,532
                                      1.60-1.70     0.17   32.75     3.63    4.24    9,723        99.97    6.64     0.71    1.34  14,524
                                      1.70-1.80     0.03   42.99     5.76    6.40    8,269       100.00    6.65     0.71    1.34  14,522
                                      1.80-SINK     0.00    0.00     0.00    0.00        0       100.00    6.65     0.71    1.34  14,522

   2 BY 1/2                          FLOAT-1.30    38.07    2.62     0.15    0.78   15,355        38.07    2.62     0.15    0.78  15,355
   PERCENT OF FLOW  38.7              1.30-1.35    30.44    4.64     0.55    1.12   14,907        68.51    3.52     0.33    0.93  15,156
                                      1.35-1.40     9.80    9.35     1.00    1.51   13,909        78.32    4.25     0.41    1.01  15,000
                                      1.40-1.50    14.49   15.92     1.52    2.08   12,682        92.80    6.07     0.59    1.17  14,638
                                      1.50-1.60     4.68   26.02     2.06    2.52   11,077        97.48    7.03     0.66    1.24  14,467
                                      1.60-1.70     1.42   33.81     3.46    3.99    9,723        98.90    7.41     0.70    1.28  14,399
                                      1.70-1.80     0.34   43.01     5.69    6.21    8,269        99.24    7.53     0.72    1.29  14,378
                                      1.80-SINK     0.76   69.61    32.65   35.48    2,841       100.00    8.01     0.96    1.56  14,290

   1/2 BY 8M                         FLOAT-1.30    41.60    2.47     0.10    0.67   15,355        41.60    2.47     0.10    0.67  15,355
   PERCENT OF FLOW   2.2              1.30-1.35    29.14    4.75     0.23    0.81   14,907        70.73    3.41     0.15    0.73  15,170
                                      1.35-1.40     3.27    9.59     0.59    1.07   13,909        80.00    4.13     0.20    0.77  15,024
                                      1.40-1.50    10.00   15.75     1.00    1.53   12,682        90.00    5.42     0.29    0.85  14,764
                                      1.50-1.60     3.77   25.82     1.69    2.10   11,077        93.77    6.24     0.35    0.91  14,616
                                      1.60-1.70     1.68   33.75     3.03    3.36    9,723        95.45    6.72     0.39    0.95  14,530
                                      1.70-1.80     0.94   41.92     4.39    4.66    8,269        96.39    7.06     0.43    0.98  14,469
                                      1.80-SINK     3.61   75.21    30.04   31.67    2,397       100.00    9.53     1.50    2.09  14,033

   COMPOSITE                         FLOAT-1.30    41.68    2.75     0.15    0.79   15,355        41.68    2.75     0.15    0.79  15,355
   FLOWRATE            166.2          1.30-1.35    28.87    4.57     0.59    1.22   14,307        70.55    3.49     0.33    0.97  15,172
                                      1.35-1.40     8.12    8.99     1.06    1.61   13,909        78.67    4.06     0.41    1.03  15,041
                                      1.40-1.50    16.90   15.67     1.66    2.24   12,682        95.56    6.11     0.63    1.25  14,624
                                      1.50-1.60     3.20   25.91     2.13    2.61   11,077        98.76    6.75     0.68    1.29  14,509
                                      1.60-1.70     0.69   33.65     3.46    3.99    9,723        99.45    6.94     0.70    1.31  14,476
                                      1.70-1.80     0.17   42.87     5.54    6.04    8,269        99.62    7.00     0.70    1.32  14,466
                                      1.80-SINK     0.38   70.80    32.07   34.63    2,742       100.00    7.24     0.82    1.44  14,421
                              SPECIFIC GRAVITY ANALYSIS OF FLOWSTREAM NUMBER 12

                       ORIGIN - UNIT NUMBER   6   R        DESTINATION - UNIT NUMBER   7

                                   SPECIFIC              DIRECT, PERCENT                                     CUMULATIVE, PERCENT
     SIZE FRACTION AND WEIGHT      GRAVITY     WEIGHT      ASH  PYRITIC   TOTAL  BTU/LB       WEIGHT      ASH  PYRITIC   TOTAL  BTU/LB
                                                                SULFUR   SULFUR                                SULFUR   SULFUR

  12 BY 6                         FLOAT-1.30    0.00      0.00     0.00    0.00       0         0.00     0.00     0.00    0.00       0
  PERCENT OF FLOW    0.2           1.30-1.35    0.00      0.00     0.00    0.00       0         0.00     0.00     0.00    0.00       0
                                   1.35-1.40    0.00      0.00     0.00    0.00       0         0.00     0.00     0.00    0.00       0
                                   1.40-1.50    0.10     16.01     1.30    1.82  12,682         0.10    16.01     1.30    1.82  12,682
                                   1.50-1.60    0.10     26.34     1.86    2.33  11,077         0.20    21.34     1.59    2.09  11,853
                                   1.60-1.70    0.12     33.93     3.12    3.69   9,723         0.32    26.04     2.16    2.69  11,058
                                   1.70-1.80    0.07     44.47     5.91    6.45   8,269         0.39    29.56     2.88    3.40  10,525
                                   1.80-SINK   99.61     99.16     0.89    0.94      79       100.00    98.89     0.89    0.95     120

  6 BY 2                          FLOAT-1.30    0.00      0.00     0.00    0.00       0         0.00     0.00     0.00    0.00       0
  PERCENT OF FLOW   75.4           1.30-1.35    0.00      0.00     0.00    0.00       0         0.00     0.00     0.00    0.00       0
                                   1.35-1.40    0.00      0.00     0.00    0.00       0         0.00     0.00     0.00    0.00       0
                                   1.40-1.50    2.61     15.54     1.74    2.33  12,682         2.61    15.54     1.74    2.33  12,682
                                   1.50-1.60    2.00     25.78     2.24    2.77  11,077         4.60    19.97     1.96    2.52  11,986
                                   1.60-1.70    2.58     32.75     3.63    4.24   9,723         7.18    24.56     2.56    3.14  11,174
                                   1.70-1.80    1.46     42.99     5.76    6.40   8,269         8.64    27.68     3.10    3.69  10,682
                                   1.80-SINK   91.36     79.45    24.47   25.68   2,016       100.00    74.98    22.63   23.78   2,765

  2 BY 1/2                        FLOAT-1.30    0.00      0.00     0.00    0.00       0         0.00     0.00     0.00    0.00       0
  PERCENT OF FLOW   23.9           1.30-1.35    0.09      4.64     0.55    1.12  14,907         0.09     4.64     0.55    1.12  14,907
                                   1.35-1.40    0.08      9.35     1.00    1.51  13,909         0.18     6.85     0.76    1.30  14,439
                                   1.40-1.50    0.62     15.92     1.52    2.08  12,682         0.79    13.88     1.35    1.91  13,076
                                   1.50-1.60    3.21     26.02     2.06    2.52  11,077         4.00    23.61     1.92    2.40  11,474
                                   1.60-1.70    3.41     33.81     3.46    3.98   9,723         7.41    28.30     2.63    3.13  10,668
                                   1.70-1.80    3.29     43.01     5.69    6.21   8,269        10.70    32.82     3.57    4.08   9,931
                                   1.80-SINK   89.30     69.61    32.65   35.48   2,841       100.00    65.67    29.54   32.12   3,600

  1/2 BY 8M                       FLOAT-1.30    0.20      2.47     0.10    0.67  15,355         0.20     2.47     0.10    0.67  15,355
  PERCENT OF FLOW    0.5           1.30-1.35    0.55      4.75     0.23    0.81  14,907         0.76     4.15     0.19    0.77  15,026
                                   1.35-1.40    0.41      9.59     0.59    1.07  13,909         1.17     6.03     0.33    0.88  14,639
                                   1.40-1.50    0.21     15.75     1.00    1.53  12,682         1.38     7.53     0.43    0.98  14,338
                                   1.50-1.60    1.48     25.82     1.69    2.10  11,077         2.86    16.97     1.08    1.56  12,655
                                   1.60-1.70    1.90     33.75     3.03    3.36   9,723         4.76    23.67     1.86    2.28  11,484
                                   1.70-1.80    2.25     41.92     4.39    4.66   8,269         7.01    29.52     2.67    3.04  10,454
                                   1.80-SINK   92.99     75.21    30.04   31.67   2,397       100.00    72.01    28.13    29.67  2,961

  COMPOSITE                       FLOAT-1.30    0.00      2.38     0.11    0.68  15,355         0.00     2.38     0.11    0.68  15,355
  FLOWRATE            85.2         1.30-1.35    0.03      4.65     0.52    1.09  14,907         0.03     4.55     0.50    1.07  14,927
                                   1.35-1.40    0.02      9.37     0.96    1.47  13,909         0.05     6.73     0.71    1.25  14,466
                                   1.40-1.50    2.11     15.56     1.72    2.31  12,682         2.16    15.37     1.70    2.29  12,722
                                   1.50-1.60    2.28     25.86     2.18    2.68  11,077         4.44    20.75     1.95    2.49  11,878
                                   1.60-1.70    2.77     33.07     3.58    4.16   9,723         7.21    25.48     2.57    3.13  11,051
                                   1.70-1.80    1.90     42.99     5.72    6.31   8,269         9.10    29.13     3.23    3.80  10,471
                                   1.80-SINK   90.90     77.18    26.35   27.94   2,206       100.00    72.80    24.25   25.74   2,958
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                                                                                        USER HANDBOOK EXAMPLE PAGE 25

                                     SPECIFIC GRAVITY ANALYSIS OF FLOWSTREAM NUMBER 11

                           ORIGIN - UNIT NUMBER   6   M        DESTINATION - UNIT NUMBER   8

                                SPECIFIC               DIRECT, PERCENT                                 CUMULATIVE, PERCENT
     SIZE FRACTION AND WEIGHT   GRAVITY     WEIGHT    ASH  PYRITIC  TOTAL   BTU/LB      WEIGHT    ASH  PYRITIC  TOTAL   BTU/LB
                                                           SULFUR  SULFUR                              SULFUR  SULFUR

 12 BY 6                        FLOAT-1.30    0.00    0.00    0.00    0.00       0        0.00    0.00    0.00    0.00       0
 PERCENT OF FLOW   0.2           1.30-1.35    0.00    0.00    0.00    0.00       0        0.00    0.00    0.00    0.00       0
                                 1.35-1.40    0.00    9.12    1.04    1.64  13,909        0.00    9.12    1.04    1.64  13,909
                                 1.40-1.50    0.23   16.01    1.30    1.82  12,682        0.23   15.88    1.29    1.82  12,705
                                 1.50-1.60    0.50   26.34    1.86    2.33  11,077        0.73   23.02    1.68    2.17  11,593
                                 1.60-1.70    0.40   33.93    3.12    3.69   9,723        1.12   26.86    2.19    2.71  10,936
                                 1.70-1.80    0.18   44.47    5.91    6.45   8,269        1.30   29.28    2.70    3.22  10,568
                                 1.80-SINK   98.70   99.16    0.89    0.94      79      100.00   98.25    0.91    0.97     216

 6 BY 2                         FLOAT-1.30    0.00    0.00    0.00    0.00       0        0.00    0.00    0.00    0.00       0
 PERCENT OF FLOW  70.3           1.30-1.35    0.00    0.00    0.00    0.00       0        0.00    0.00    0.00    0.00       0
                                 1.35-1.40    0.05    8.62    1.13    1.73  13,909        0.05    8.62    1.13    1.73  13,909
                                 1.40-1.50    5.40   15.54    1.74    2.33  12,682        5.46   15.47    1.73    2.32  12,694
                                 1.50-1.60    6.96   25.78    2.24    2.77  11,077       12.42   21.25    2.02    2.57  11,787
                                 1.60-1.70    6.94   32.75    3.63    4.24   9,723       19.36   25.37    2.60    3.17  11,047
                                 1.70-1.80    2.89   42.99    5.76    6.40   8,269       22.25   27.66    3.01    3.59  10,686
                                 1.80-SINK   77.75   79.45   24.47   25.68   2,016      100.00   67.93   19.70   20.77   3,945

 2 BY 1/2                       FLOAT-1.30    0.00    0.00    0.00    0.00       0        0.00    0.00    0.00    0.00       0
 PERCENT OF FLOW  28.0           1.30-1.35    0.01    4.64    0.55    1.12  14,907        0.01    4.64    0.55    1.12  14,907
                                 1.35-1.40    0.12    9.35    1.00    1.51  13,909        0.13    9.15    0.98    1.49  13,951
                                 1.40-1.50    2.02   15.92    1.52    2.08  12,682        2.15   15.52    1.49    2.05  12,757
                                 1.50-1.60    6.76   26.02    2.06    2.52  11,077        8.91   23.48    1.92    2.41  11,483
                                 1.60-1.70    6.97   33.81    3.46    3.98   9,723       15.88   28.02    2.60    3.10  10,710
                                 1.70-1.80    5.05   43.01    5.69    6.21   8,269       20.93   31.64    3.34    3.85  10,121
                                 1.80-SINK   79.07   69.61   32.65   35.48   2,841      100.00   61.66   26.52   28.86   4,365

 1/2 BY 8M                      FLOAT-1.30    1.19    2.47    0.10    0.67  15,355        1.19    2.47    0.10    0.67  15,355
 PERCENT OF FLOW   1.5           1.30-1.35    1.48    4.75    0.23    0.81  14,907        2.67    3.74    0.17    0.75  15,107
                                 1.35-1.40    1.01    9.59    0.59    1.07  13,909        3.67    5.34    0.28    0.84  14,779
                                 1.40-1.50    3.66   15.75    1.00    1.53  12,682        7.33   10.53    0.64    1.19  13,733
                                 1.50-1.60    4.50   25.82    1.69    2.10  11,077       11.83   16.35    1.04    1.53  12,723
                                 1.60-1.70    4.47   33.75    3.03    3.36   9,723       16.31   21.12    1.58    2.04  11,900
                                 1.70-1.80    4.44   41.92    4.39    4.66   8,269       20.75   25.58    2.19    2.60  11,122
                                 1.80-SINK   79.25   75.21   30.04   31.67   2,397      100.00   64.91   24.26   25.64   4,207

 COMPOSITE                      FLOAT-1.30    0.02    2.47    0.10    0.67  15,355        0.02    2.47    0.10    0.67  15,355
 FLOWRATE            44.9        1.30-1.35    0.02    4.75    0.25    0.83  14,907        0.04    3.77    0.18    0.76  15,099
                                 1.35-1.40    0.09    9.08    0.98    1.53  13,909        0.13    7.35    0.72    1.28  14,297
                                 1.40-1.50    4.42   15.59    1.70    2.29  12,682        4.55   15.36    1.68    2.26  12,727
                                 1.50-1.60    6.85   25.84    2.19    2.69  11,077       11.40   21.66    1.98    2.52  11,735
                                 1.60-1.70    6.90   33.06    3.58    4.16   9,723       18.30   25.96    2.58    3.14  10,977
                                 1.70-1.80    3.52   42.98    5.71    6.29   8,269       21.82   28.70    3.09    3.65  10,541
                                 1.80-SINK   78.18   76.65   26.81   28.48   2,250      100.00   66.19   21.64   23.06   4,059
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                        SUMMARY OF THE PERFORMANCE CHARACTERISTICS OF UNIT NUMBER  7

                                               STREAM BLENDER

SIZE, INCHES OR MESH                          18        12         6         2       1/2        8M       28M      100M      COMP
                                              BY        BY        BY        BY        BY        BY        BY        BY
                                              12         6         2       1/2        8M       28M      100M      325M

SCREEN ANALYSIS, PERCENT-
   PRODUCT..............................   10.19     33.78     42.33     13.42      0.27      0.00      0.00      0.00    100.00
   FEED 1...............................   23.20     76.80      0.00      0.00      0.00      0.00      0.00      0.00    100.00
   FEED 2...............................    0.05      0.21     75.36     23.90      0.48      0.00      0.00      0.00    100.00

ASH, PERCENT
   PRODUCT..............................   97.73     94.55     74.98     65.67     72.01     45.85     50.40     48.13     82.65
   FEED 1...............................   97.73     94.54      0.00      0.00      0.00      0.00      0.00      0.00     95.28
   FEED 2...............................   99.53     98.89     74.98     65.67     72.01     45.85     50.40     48.13     72.80

PYRITIC SULFUR, PERCENT
   PRODUCT..............................    0.43      0.97     22.63     29.54     28.13     16.07     21.69     22.90     13.99
   FEED 1...............................    0.43      0.97      0.00      0.00      0.00      0.00      0.00      0.00      0.84
   FEED 2...............................    0.42      0.89     22.63     29.54     28.13     16.07     21.69     22.90     24.25

TOTAL SULFUR, PERCENT
   PRODUCT..............................    0.46      1.05     23.78     32.12     29.67     17.02     22.89     23.92     14.86
   FEED 1...............................    0.46      1.05      0.00      0.00      0.00      0.00      0.00      0.00      0.92
   FEED 2...............................    0.44      0.95     23.78     32.12     29.67     17.02     22.89     23.92     25.74

BTU/LB, MOISTURE FREE
   PRODUCT..............................     332       793     2,765     3,600     2,961     7,540     5,271     5,080     1,963
   FEED 1...............................     333       795         0         0         0         0         0         0       688
   FEED 2...............................      54       120     2,765     3,600     2,961     7,540     5,271     5,080     2,958
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                              SPECIFIC GRAVITY ANALYSIS OF FLOWSTREAM NUMBER 13

                      ORIGIN - UNIT NUMBER   7   R        DESTINATION - UNIT NUMBER  12

                                 SPECIFIC              DIRECT, PERCENT                                   CUMULATIVE, PERCENT
      SIZE FRACTION AND WEIGHT   GRAVITY    WEIGHT    ASH  PYRITIC   TOTAL  BTU/LB       WEIGHT     ASH  PYRITIC   TOTAL  BTU/LB
                                                               SULFUR  SULFUR                                   SULFUR  SULFUR

     18 BY 12                   FLOAT-1.30    0.85    2.80    0.21    0.79  15,355         0.85    2.80    0.21    0.79  15,355
     PERCENT OF FLOW  10.2       1.30-1.35    0.48    4.40    0.71    1.57  14,907         1.33    3.37    0.39    1.07  15,194
                                 1.35-1.40    0.09    7.80    0.98    1.59  13,909         1.42    3.66    0.43    1.10  15,112
                                 1.40-1.50    0.49   15.40    1.10    1.60  12,682         1.91    6.67    0.60    1.23  14,489
                                 1.50-1.60    0.09   25.00    1.44    1.84  11,077         2.00    7.50    0.64    1.26  14,334
                                 1.60-1.70    0.08   31.50    2.90    3.50   9,723         2.08    8.45    0.73    1.35  14,152
                                 1.70-1.80    0.03   41.00    5.46    6.13   8,269         2.11    8.98    0.80    1.43  14,055
                                 1.80-SINK   97.89   99.65    0.42    0.44      35       100.00   97.73    0.43    0.46     332

     12 BY 6                    FLOAT-1.30    1.82    2.87    0.19    0.80  15,355         1.82    2.87    0.19    0.80  15,355
     PERCENT OF FLOW  33.8       1.30-1.35    1.38    4.63    0.64    1.31  14,907         3.20    3.62    0.38    1.02  15,162
                                 1.35-1.40    0.45    9.17    1.04    1.64  13,909         3.64    4.31    0.47    1.09  15,008
                                 1.40-1.50    0.73   16.08    1.32    1.85  12,682         4.38    6.28    0.61    1.22  14,618
                                 1.50-1.60    0.36   26.39    1.87    2.36  11,077         4.74    7.82    0.71    1.31  14,347
                                 1.60-1.70    0.21   34.09    3.14    3.70   9,723         4.95    8.94    0.81    1.41  14,150
                                 1.70-1.80    0.11   44.65    5.93    6.46   8,269         5.07    9.73    0.92    1.52  14,020
                                 1.80-SINK   94.93   99.08    0.97    1.03      87       100.00   94.55    0.97    1.05     793

     6 BY 2                     FLOAT-1.30    0.00    0.00    0.00    0.00       0         0.00    0.00    0.00    0.00       0
     PERCENT OF FLOW  42.3       1.30-1.35    0.00    0.00    0.00    0.00       0         0.00    0.00    0.00    0.00       0
                                 1.35-1.40    0.00    0.00    0.00    0.00       0         0.00    0.00    0.00    0.00       0
                                 1.40-1.50    2.61   15.54    1.74    2.33  12,682         2.61   15.54    1.74    2.33  12,682
                                 1.50-1.60    2.00   25.78    2.24    2.77  11,077         4.60   19.97    1.96    2.52  11,986
                                 1.60-1.70    2.58   32.75    3.63    4.24   9,723         7.18   24.56    2.56    3.14  11,174
                                 1.70-1.80    1.46   42.99    5.76    6.40   8,269         8.64   27.68    3.10    3.69  10,682
                                 1.80-SINK   91.36   79.45   24.47   25.68   2,016       100.00   74.98   22.63   23.78   2,765

     2 BY 1/2                   FLOAT-1.30    0.00    0.00    0.00    0.00       0         0.00    0.00    0.00    0.00       0
     PERCENT OF FLOW  13.4       1.30-1.35    0.09    4.64    0.55    1.12  14,907         0.09    4.64    0.55    1.12  14,907
                                 1.35-1.40    0.08    9.35    1.00    1.51  13,909         0.18    6.85    0.76    1.30  14,439
                                 1.40-1.50    0.62   15.92    1.52    2.08  12,682         0.79   13.88    1.35    1.91  13,076
                                 1.50-1.60    3.21   26.02    2.06    2.52  11,077         4.00   23.61    1.92    2.40  11,474
                                 1.60-1.70    3.41   33.81    3.46    3.98   9,723         7.41   28.30    2.63    3.13  10,668
                                 1.70-1.80    3.29   43.01    5.69    6.21   8,269        10.70   32.82    3.57    4.08   9,931
                                 1.80-SINK   89.30   69.61   32.65   35.48   2,841       100.00   65.67   29.54   32.12   3,600

     1/2 BY 8M                  FLOAT-1.30    0.20    2.47    0.10    0.67  15,355         0.20    2.47    0.10    0.67  15,355
     PERCENT OF FLOW   0.3       1.30-1.35    0.56    4.75    0.23    0.81  14,907         0.76    4.15    0.19    0.77  15,026
                                 1.35-1.40    0.41    9.59    0.59    1.07  13,909         1.17    6.03    0.33    0.88  14,639
                                 1.40-1.50    0.21   15.75    1.00    1.53  12,682         1.38    7.53    0.43    0.98  14,338
                                 1.50-1.60    1.48   25.82    1.69    2.10  11,077         2.86   16.97    1.08    1.56  12,655
                                 1.60-1.70    1.90   33.75    3.03    3.36   9,723         4.76   23.67    1.86    2.28  11,484
                                 1.70-1.80    2.25   41.92    4.39    4.66   8,269         7.01   29.52    2.67    3.04  10,454
                                 1.80-SINK   92.99   75.21   30.04   31.67   2,397       100.00   72.01   28.13   29.67   2,961
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                                                                                              USER HANDBOOK EXAMPLE PAGE 28

                                    SPECIFIC GRAVITY ANALYSIS OF FLOWSTREAM NUMBER 13 (CONTINUED)

                                ORIGIN - UNIT NUMBER   7   R        DESTINATION - UNIT NUMBER  12

                                                          DIRECT, PERCENT                                  CUMULATIVE, PERCENT
                                      SPECIFIC                   ASH  PYRITIC   TOTAL   BTU/LB      WEIGHT    ASH  PYRITIC   TOTAL   BTU/LB
      SIZE FRACTION AND WEIGHT        GRAVITY      WEIGHT              SULFUR  SULFUR                                 SULFUR  SULFUR

COMPOSITE                          FLOAT-1.30      0.70     2.86     0.19     0.80  15,355        0.70     2.86     0.19     0.80  15,355
FLOWRATE             151.7          1.30-1.35      0.53     4.61     0.65     1.33  14,907        1.23     3.61     0.39     1.02  15,163
                                    1.35-1.40      0.17     9.11     1.03     1.63  13,909        1.40     4.29     0.47     1.10  15,008
                                    1.40-1.50      1.49    15.64     1.64     2.21  12,682        2.89    10.13     1.07     1.67  13,812
                                    1.50-1.60      1.41    25.90     2.15     2.65  11,077        4.30    15.30     1.42     1.99  12,915
                                    1.60-1.70      1.63    33.10     3.56     4.14   9,723        5.93    20.20     2.01     2.58  12,036
                                    1.70-1.80      1.11    43.04     5.73     6.31   8,269        7.04    23.80     2.60     3.17  11,443
                                    1.80-SINK     92.96    87.11    14.85    15.75   1,245      100.00    82.65    13.99    14.86   1,963
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                                                                                                USER HANDBOOK EXAMPLE PAGE 29

                                    SUMMARY OF THE PERFORMANCE CHARACTERISTICS OF UNIT NUMBER  8

                                                  SECONDARY MULTIPLE ROLL CRUSHER
                                                  CRUSHER SETTING = 0.28 INCHES

SIZE, INCHES OR MESH                             12         6         2       1/2        8M       28M      100M      COMP
                                                 BY        BY        BY        BY        BY        BY        BY
                                                  6         2       1/2        8M       28M      100M      325M

SCREEN ANALYSIS, PERCENT-
    FEED...................................    0.16     70.31     27.95      1.50      0.03      0.00      0.00    100.00
    CRUSHED COAL...........................    0.00      0.00      0.00      8.67     64.83     19.82      6.68    100.00

ASH, PERCENT
    FEED...................................   98.25     67.93     61.66     64.91     68.57     60.40     57.79     66.19
    CRUSHEU COAL...........................    0.00      0.00      0.00     66.22     66.23     66.07     66.12     66.19

PYRITIC SULFUR, PERCENT
    FEED...................................    0.91     19.70     26.52     24.26     25.35     26.81     28.07     21.64
    CRUSHED COAL...........................    0.00      0.00      0.00     21.61     21.59     21.76     21.71     21.64

TOTAL SLLFUR, PERCENT
    FEED...................................    0.97     20.77     28.86     25.64     26.57     28.17     29.21     23.06
    CRUSHED COAL...........................    0.00      0.00      0.00     23.03     23.01     23.22     23.15     23.06

BTU/LB, MOISTURE FREE
    FEED...................................     216     3,945     4,365     4,207     3,517     3,150     2,968     4,059
    CRUSHED COAL...........................       0         0         0     4,057     4,056     4,067     4,063     4,059
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                                                                                           USER HANDBOOK EXAMPLE PAGE 30

                                   SPECIFIC GRAVITY ANALYSIS OF FLOWSTREAM NUMBER 14

                            ORIGIN - UNIT NUMBER   8   M       DESTINATION - UNIT NUMBER   9

                                                         DIRECT, PERCENT                             CUMULATIVE, PERCENT
                                  SPECIFIC                ASH  PYRITIC   TOTAL  BTU/LB      WEIGHT   ASH  PYRITIC  TOTAL  BTU/LB
   SIZE FRACTION AND WEIGHT       GRAVITY     WEIGHT           SULFUR   SULFUR                            SULFUR   SULFUR

1/2 BY 8M                        FLOAT-1.30    0.03    2.47    0.10    0.67  15,355       0.03   2.47    0.10    0.67  15,355
PERCENT OF FLOW   8.7             1.30-1.35    0.04    4.75    0.24    0.82  14,907       0.07   3.76    0.18    0.76  15,102
                                  1.35-1.40    0.09    9.12    0.95    1.49  13,909       0.16   6.92    0.63    1.19  14,398
                                  1.40-1.50    4.44   15.59    1.70    2.28  12,682       4.60  15.29    1.66    2.25  12,741
                                  1.50-1.60    6.84   25.84    2.19    2.69  11,077      11.43  21.60    1.98    2.51  11,746
                                  1.60-1.70    6.88   33.06    3.58    4.16   9,723      18.31  25.90    2.58    3.13  10,987
                                  1.70-1.80    3.51   42.97    5.69    6.27   8,269      21.82  28.64    3.08    3.64  10,550
                                  1.80-SINK   78.18   76.71   26.78   28.44   2,245     100.00  66.22   21.61   23.03   4,057

8M BY 28M                        FLOAT-1.30    0.02    2.47    0.10    0.67  15,355       0.02   2.47    0.10    0.67  15,355
PERCENT OF FLOW  64.8             1.30-1.35    0.02    4.75    0.25    0.83  14,907       0.04   3.77    0.18    0.76  15,098
                                  1.35-1.40    0.09    9.07    0.99    1.53  13,909       0.12   7.39    0.73    1.29  14,286
                                  1.40-1.50    4.44   15.59    1.70    2.29  12,682       4.57  15.36    1.68    2.26  12,726
                                  1.50-1.60    6.86   25.84    2.19    2.70  11,077      11.42  21.65    1.99    2.52  11,736
                                  1.60-1.70    6.90   33.05    3.58    4.16   9,723      18.32  25.94    2.59    3.14  10,978
                                  1.70-1.80    3.50   42.98    5.71    6.29   8,269      21.82  28.68    3.09    3.65  10,543
                                  1.80-SINK   78.18   76.71   26.76   28.42   2,245     100.00  66.23   21.59   23.01   4,056

28M BY 100M                      FLOAT-1.30    0.02    2.47    0.10    0.67  15,355       0.02   2.47    0.10    0.67  15,355
PERCENT OF FLOW  19.8             1.30-1.35    0.02    4.75    0.25    0.83  14,907       0.04   3.78    0.19    0.77  15,097
                                  1.35-1.40    0.09    9.08    0.99    1.53  13,909       0.12   7.45    0.74    1.30  14,274
                                  1.40-1.50    4.36   15.59    1.70    2.29  12,682       4.48  15.37    1.67    2.26  12,726
                                  1.50-1.60    6.85   25.85    2.19    2.69  11,077      11.34  21.70    1.98    2.52  11,729
                                  1.60-1.70    6.90   33.08    3.58    4.16   9,723      18.24  26.01    2.59    3.14  10,970
                                  1.70-1.80    3.56   42.98    5.71    6.29   8,269      21.79  28.78    3.10    3.65  10,529
                                  1.80-SINK   78.21   76.46   26.97   28.67   2,266     100.00  66.07   21.76   23.22   4,067

100M BY 325M                     FLOAT-1.30    0.02    2.47    0.10    0.67  15,355       0.02   2.47    0.10    0.67  15,355
PERCENT OF FLOW   6.7             1.30-1.35    0.03    4.72    0.25    0.83  14,907       0.04   3.77    0.18    0.76  15,097
                                  1.35-1.40    0.09    9.04    0.97    1.52  13,909       0.13   7.29    0.71    1.27  14,305
                                  1.40-1.50    4.39   15.59    1.70    2.29  12,682       4.52  15.35    1.67    2.26  12,730
                                  1.50-1.60    6.85   25.84    2.19    2.69  11,077      11.37  21.67    1.98    2.52  11,734
                                  1.60-1.70    6.89   33.07    3.58    4.16   9,723      18.26  25.97    2.58    3.14  10,975
                                  1.70-1.80    3.54   42.98    5.71    6.28   8,269      21.80  28.73    3.09    3.65  10,536
                                  1.80-SINK   78.20   76.54   26.90   28.59   2,259     100.00  66.12   21.71   23.15   4,063

COMPOSITE                        FLOAT-1.30    0.02    2.47    0.10    0.67  15,355       0.02   2.47    0.10    0.67  15,355
FLOWRATE           44.9           1.30-1.35    0.02    4.75    0.25    0.83  14,907       0.04   3.77    0.18    0.76  15,099
                                  1.35-1.40    0.09    9.08    0.98    1.53  13,909       0.13   7.35    0.72    1.28  14,297
                                  1.40-1.50    4.42   15.59    1.70    2.29  12,682       4.55  15.36    1.68    2.26  12,727
                                  1.50-1.60    6.85   25.84    2.19    2.69  11,077      11.40  21.66    1.98    2.52  11,735
                                  1.60-1.70    6.90   33.06    3.58    4.16   9,723      18.30  25.96    2.58    3.14  10,977
                                  1.70-1.80    3.52   42.98    5.71    6.29   8,269      21.82  28.70    3.09    3.65  10,541
                                  1.80-SINK   78.18   76.65   26.81   28.48   2,250     100.00  66.19   21.64   23.06   4,059
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                                                                                   USER HANDBOOK EXAMPLE PAGE 31
                                      SUMMARY OF THE PERFORMANCE CHARACTERISTICS OF UNIT NUMBER  9

                                                          STREAM BLENDER

SIZE, INCHES OR MESH                                1/2        8M        28M       100M      COMP
                                                     BY        BY         BY        BY
                                                     8M       28M       100M      325M

SCREEN ANALYSIS, PERCENT-
    PRODUCT.................................     40.71     33.21      15.01     11.06     100.00
    FEED 1..................................     50.82     23.24      13.50     12.44     100.00
    FEED 2..................................      8.67     64.83      19.82      6.68     100.00

ASH, PERCENT
    PRODUCT.................................     24.98     40.54      29.42     19.44      30.20
    FEED 1..................................     22.75     17.93      12.44     11.54      18.85
    FEED 2..................................     66.22     66.23      66.07     66.12      65.19

PYRITIC SULFUR, PERCENT
    PRODUCT.................................      7.77     12.99       9.67      6.53       9.68
    FEED 1..................................      7.02      5.42       4.06      4.31       5.91
    FEED 2..................................     21.61     21.59      21.76     21.71      21.64

TOTAL SULFUR, PERCENT
    PRODUCT.................................      8.58     14.00      10.57      7.58      10.57
    FEED 1..................................      7.80      6.07       4.71      4.94       6.63
    FEED 2..................................     23.03     23.01      23.22     23.15      23.06

BTU/LB, MOISTURE FREE
    PRODUCT................................. 11,297      8,538     10,320    11,709     10,280
    FEED 1.................................. 11,687     12,484     13,217    13,004     12,243
    FEED 2..................................  4,057      4,056      4,067     4,063      4,059
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                                SPECIFIC GRAVITY ANALYSIS OF FLOWSTREAM NUMBER 15

                      ORIGIN - UNIT NUMBER   9   M       DESTINATION - UNIT NUMBER  10

                                                                                        CUMULATIVE, PERCENT
                                 SPECIFIC              DIRECT, PERCENT                               ASH  PYRITIC   TOTAL   BTU/LB
    SIZE FRACTION AND WEIGHT     GRAVITY    WEIGHT    ASH  PYRITIC  TOTAL  BTU/LB       WEIGHT            SULFUR  SULFUR
                                                             SULFUR  SULFUR

                                FLOAT-1.30   30.66    2.47    0.10    0.67  15,355       30.66    2.47    0.10    0.67  15,355
1/2 BY 8M                        1.30-1.35   21.60    4.75    0.23    0.81  14,907       52.26    3.41    0.15    0.73  15,170
PERCENT OF FLOW  40.7            1.35-1.40    6.97    9.58    0.59    1.07  13,909       59.22    4.14    0.20    0.77  15,022
                                 1.40-1.50    8.06   15.75    1.02    1.56  12,682       67.28    5.53    0.30    0.86  14,741
                                 1.50-1.60    3.84   25.82    1.73    2.16  11,077       71.12    6.63    0.38    0.93  14,543
                                 1.60-1.70    2.34   33.65    3.11    3.48   9,723       73.46    7.49    0.46    1.02  14,390
                                 1.70-1.80    1.65   42.03    4.53    4.84   8,269       75.10    8.24    0.55    1.10  14,256
                                 1.80-SINK   24.90   75.45   29.52   31.15   2,373      100.00   24.98    7.77    8.58  11,297

                                FLOAT-1.30   23.36    1.95    0.18    0.68  15,355       23.36    1.95    0.18    0.68  15,355
8M BY 28M                        1.30-1.35   11.05    4.44    0.41    0.94  14,907       34.41    2.75    0.26    0.77  15,211
PERCENT OF FLOW  33.2            1.35-1.40    3.42    9.05    0.88    1.38  13,909       37.83    3.32    0.31    0.82  15,093
                                 1.40-1.50    5.38   15.57    1.48    2.03  12,682       43.21    4.85    0.46    0.97  14,793
                                 1.50-1.60    4.74   25.58    2.14    2.63  11,077       47.95    6.89    0.62    1.14  14,426
                                 1.60-1.70    4.15   33.14    3.52    4.09   9,723       52.10    8.98    0.85    1.37  14,052
                                 1.70-1.80    2.32   42.66    5.70    6.22   8,269       54.42   10.42    1.06    1.58  13,805
                                 1.80-SINK   45.58   76.51   27.24   28.84   2,250      100.00   40.54   12.99   14.00   8,538

                                FLOAT-1.30   37.41    1.86    0.16    0.72  15,355       37.41    1.86    0.16    0.72  15,355
28M BY 100M                      1.30-1.35   10.54    5.61    0.58    1.10  14,907       47.95    2.6[illegible]    0.25    0.80  15,257
PERCENT OF FLOW  15.0            1.35-1.40    5.56    8.52    0.97    1.45  13,909       53.51    3.29    0.33    0.87  15,117
                                 1.40-1.50    4.86   15.56    1.72    2.29  12,682       58.38    4.31    0.44    0.99  14,914
                                 1.50-1.60    3.82   24.97    2.42    2.90  11,077       62.19    5.58    0.56    1.11  14,678
                                 1.60-1.70    3.08   32.39    3.68    4.27   9,723       65.27    6.84    0.71    1.26  14,445
                                 1.70-1.80    1.71   41.32    5.77    6.35   8,269       66.99    7.73    0.84    1.39  14,287
                                 1.80-SINK   33.01   73.45   27.57   29.21   2,271      100.00   29.42    9.67   10.57  10,320

                                FLOAT-1.30   35.21    1.43    0.12    0.66  15,355       35.21    1.43    0.12    0.66  15,355
100M BY 325M                     1.30-1.35   19.27    3.21    0.33    0.89  14,907       54.47    2.06    0.19    0.74  15,137
PERCENT OF FLOW  11.1            1.35-1.40   11.81    4.86    0.49    1.07  13,909       66.29    2.56    0.25    0.80  14,967
                                 1.40-1.50    5.48   12.56    1.31    1.84  12,682       71.77    3.32    0.33    0.88  14,793
                                 1.50-1.60    3.06   21.53    2.34    2.88  11,077       74.82    4.07    0.41    0.96  14,641
                                 1.60-1.70    1.97   29.89    3.77    4.24   9,723       76.80    4.73    0.50    1.05  14,515
                                 1.70-1.80    1.06   38.94    6.24    6.82   8,269       77.85    5.19    0.57    1.12  14,430
                                 1.80-SINK   22.15   69.53   28.83   30.28   2,145      100.00   19.44    6.83    7.58  11,709

                                FLOAT-1.30   29.75    2.08    0.13    0.68  15,355       29.75    2.08    0.13    0.68  15,355
COMPOSITE                        1.30-1.35   16.18    4.56    0.32    0.88  14,907       45.93    2.96    0.20    0.75  15,197
FLOWRATE            187.1        1.35-1.40    6.11    8.33    0.67    1.18  13,909       52.04    3.59    0.25    0.80  15,046
                                 1.40-1.50    6.40   15.38    1.25    1.80  12,682       58.45    4.88    0.36    0.91  14,787
                                 1.50-1.60    4.05   25.25    2.04    2.51  11,077       62.49    6.20    0.47    1.02  14,547
                                 1.60-1.70    3.01   32.95    3.44    3.94   9,723       65.50    7.43    0.61    1.15  14,325
                                 1.70-1.80    1.82   42.00    5.31    5.77   8,269       67.32    8.36    0.74    1.27  14,162
                                 1.80-SINK   32.68   75.19   28.12   29.72   2,283      100.00   30.20    9.68   10.57  10,280
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                    SUMMARY OF THE PERFORMANCE CHARACTERISTICS OF UNIT NUMBER 10

                                                WET SINGLE DECK SCREEN
                                             SIZE OF OPENING = 0.02 INCHES

SIZE, INCHES OR MESH                                 1/2        8M       28M      100M      COMP
                                                      BY        BY        BY        BY
                                                      8M       28M      100M      325M

SCREEN ANALYSIS, PERCENT-
   FEED.....................................       40.71     33.21     15.01     11.06    100.00
   OVERFLOW (COARSE) STREAM.................       44.88     36.62     12.26      6.24    100.00
   UNDERFLOW (FINE) STREAM..................        0.00      0.00     41.86     58.14    100.00

ASH, PERCENT
   FEED.....................................       24.98     40.54     29.42     19.44     30.20
   OVERFLOW (COARSE) STREAM.................       24.98     40.54     29.42     19.44     30.88
   UNDERFLOW (FINE) STREAM..................        0.00      0.00     29.42     19.44     23.62

PYRITIC SULFUR, PERCENT
   FEED.....................................        7.77     12.99      9.67      6.83      9.68
   OVERFLOW (COARSE) STREAM.................        7.77     12.99      9.67      6.83      9.85
   UNDERFLOW (FINE) STREAM..................        0.00      0.00      9.67      6.83      8.02

TOTAL SULFUR, PERCENT
   FEED.....................................        8.58     14.00     10.57      7.58     10.57
   OVERFLOW (COARSE) STREAM.................        8.58     14.00     10.57      7.58     10.75
   UNDERFLOW (FINE) STREAM..................        0.00      0.00     10.57      7.58      8.83

BTU/LB, MOISTURE FREE
   FEED.....................................      11,297     8,538    10,320    11,709    10,280
   OVERFLOW (COARSE) STREAM.................      11,297     8,538    10,320    11,709    10,193
   UNDERFLOW (FINE) STREAM..................           0         0    10,320    11,709    11,128

WEIGHT RATIO, UNDERFLOW TO FEED.... PERCENT          0.0       0.0      25.9      48.9       9.3
BTU RATIO, UNDERFLOW TO FEED.......      DO          0.0       0.0      25.9      48.9      10.1
UNDERSIZE MATERIAL IN OVERFLOW STREAM.   DO          0.0       0.0      12.3       6.2      18.5
OVERSIZE MATERIAL IN UNDERFLOW STREAM.   DO          0.0       0.0       0.0       0.0       0.0
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                              SPECIFIC GRAVITY ANALYSIS OF FLOWSTREAM NUMBER 16

                       ORIGIN - UNIT NUMBER  10   U       DESTINATION - UNIT NUMBER  11

                                     SPECIFIC             DIRECT, PERCENT                                     CUMULATIVE, PERCENT
      SIZE FRACTION AND WEIGHT       GRAVITY     WEIGHT      ASH  PYRITIC   TOTAL   BTU/LB       WEIGHT     ASH  PYRITIC    TOTAL   BTU/LB
                                                                  SULFUR   SULFUR                                 SULFUR   SULFUR

  1/2 BY 8M                         FLOAT-1.30    30.66     2.47     0.10     0.67  15,355        30.66    2.47     0.10     0.67  15,355
  PERCENT OF FLOW  44.9              1.30-1.35    21.60     4.75     0.23     0.81  14,907        52.26    3.41     0.15     0.73  15,170
                                     1.35-1.40     6.97     9.58     0.59     1.07  13,909        59.22    4.14     0.20     0.77  15,022
                                     1.40-1.50     8.06    15.75     1.02     1.56  12,682        67.28    5.53     0.30     0.86  14,741
                                     1.50-1.60     3.84    25.82     1.73     2.16  11,077        71.12    6.63     0.38     0.93  14,543
                                     1.60-1.70     2.34    33.65     3.11     3.48   9,723        73.46    7.49     0.46     1.02  14,390
                                     1.70-1.80     1.65    42.03     4.53     4.84   8,269        75.10    8.24     0.55     1.10  14,256
                                     1.80-SINK    24.90    75.45    29.52    31.15   2,373       100.00   24.98     7.77     8.58  11,297

  8M BY 28M                         FLOAT-1.30    23.36     1.95     0.18     0.68  15,355        23.36    1.95     0.18     0.68  15,355
  PERCENT OF FLOW  36.6              1.30-1.35    11.05     4.44     0.41     0.94  14,907        34.41    2.75     0.26     0.77  15,211
                                     1.35-1.40     3.42     9.05     0.88     1.38  13,909        37.83    3.32     0.31     0.82  15,093
                                     1.40-1.50     5.38    15.57     1.48     2.03  12,682        43.21    4.85     0.46     0.97  14,793
                                     1.50-1.60     4.74    25.58     2.14     2.63  11,077        47.95    6.89     0.62     1.14  14,426
                                     1.60-1.70     4.15    33.14     3.52     4.09   9,723        52.10    8.98     0.85     1.37  14,052
                                     1.70-1.80     2.32    42.66     5.70     6.22   8,269        54.42   10.42     1.06     1.58  13,805
                                     1.80-SINK    45.58    76.51    27.24    28.84   2,250       100.00   40.54    12.99    14.00   8,538

  28M BY 100M                       FLOAT-1.30    37 41     1.86     0.16     0.72  15,355        37.41    1.86     0.16     0.72  15,355
  PERCENT OF FLOW  12.3              1.30-1.35    10.54     5.61     0.58     1.10  14,907        47.95    2.68     0.25     0.80  15,257
                                     1.35-1.40     5.56     8.52     0.97     1.45  13,909        53.51    3.29     0.33     0.87  15,117
                                     1.40-1.50     4.86    15.56     1.72     2.29  12,682        58.38    4.31     0.44     0.99  14,914
                                     1.50-1.60     3.82    24.97     2.42     2.90  11,077        62.19    5.58     0.56     1.11  14,678
                                     1.60-1.70     3.08    32.39     3.68     4.27   9,723        65.27    6.84     0.71     1.26  14,445
                                     1.70-1.80     1.71    41.32     5.77     6.35   8,269        66.99    7.73     0.84     1.39  14,287
                                     1.80-SINK    33.01    73.45    27.57    29.21   2,271       100.00   29.42     9.67    10.57  10,320

  100M BY 325M                      FLCAT-1.30    35.21     1.43     0.12     0.66  15,355        35.21    1.43     0.12     0.66  15,355
  PERCENT OF FLOW   6.2              1.30-1.35    19.27     3.21     0.33     0.88  14,907        54.47    2.06     0.19     0.74  15,197
                                     1.35-1.40    11.81     4.86     0.49     1.07  13,909        66.29    2.56     0.25     0.80  14,967
                                     1.40-1.50     5.48    12.56     1.31     1.84  12,682        71.77    3.32     0.33     0.88  14,793
                                     1.50-1.60     3.06    21.53     2.34     2.88  11,077        74.82    4.07     0.41     0.96  14,641
                                     1.60-1.70     1.97    29.89     3.77     4.24   9,723        76.80    4.73     0.50     1.05  14,515
                                     1.70-1.80     1.06    38.94     6.24     6.82   8,269        77.85    5.19     0.57     1.12  14,430
                                     1.80-SINK    22.15    69.53    28.83    30.28   2,145       100.00   19.44     6.83     7.58  11,709

  COMPOSITE                         FLOAT-1.30    29.10     2.14     0.13     0.68  15,355        29.10    2.14     0.13     0.68  15,355
  FLOWRATE            169.7          1.30-1.35    16.23     4.63     0.31     0.87  14,907        45.33    3.03     0.20     0.75  15,195
                                     1.35-1.40     5.80     8.74     0.68     1.18  13,909        51.13    3.69     0.25     0.80  15,049
                                     1.40-1.50     6.53    15.51     1.24     1.78  12,682        57.66    5.02     0.36     0.91  14,781
                                     1.50-1.60     4.12    25.42     2.01     2.47  11,077        61.77    6.38     0.47     1.01  14,534
                                     1.60-1.70     3.07    33.09     3.41     3.91   9,723        64.84    7.64     0.61     1.15  14,306
                                     1.70-1.80     1.87    42.13     5.26     5.71   8,269        66.71    8.61     0.74     1.28  14,138
                                     1.80-SINK    33.29    75.49    28.11    29.72   2,290       100.00   30.88     9.85    10.75  10,193
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                                                                                                    USER HANDBOOK EXAMPLE PAGE 35

                                                 SPECIFIC GRAVITY ANALYSIS OF FLOWSTREAM NUMBER 17

                                       ORIGIN - UNIT NUMBER  10    L         DESTINATION - UNIT NUMBER  13

                                             SPECIFIC              DIRECT, PERCENT                                  CUMULATIVE, PERCENT
      SIZE FRACTION AND WEIGHT               GRAVITY      WEIGHT     ASH  PYRITIC   TOTAL   BTU/LB       WEIGHT     ASH  PYRITIC   TOTAL   BTU/LB
                                                                          SULFUR   SULFUR                                 SULFUR   SULFUR

  28M BY 100M                               FLOAT-1.30     37.41     1.86     0.16     0.72  15,355        37.41     1.86     0.16     0.72  15,355
  PERCENT OF FLOW  41.9                      1.30-1.35     10.54     5.61     0.58     1.10  14,907        47.95     2.68     0.25     0.80  15,257
                                             1.35-1.40      5.56     8.52     0.97     1.45  13,909        53.51     3.29     0.33     0.87  15,117
                                             1.40-1.50      4.86    15.56     1.72     2.29  12,682        58.38     4.31     0.44     0.99  14,914
                                             1.50-1.60      3.82    24.97     2.42     2.90  11,077        62.19     5.58     0.56     1.11  14,678
                                             1.60-1.70      3.08    32.39     3.68     4.27   9,723        65.27     6.84     0.71     1.26  14,445
                                             1.70-1.80      1.71    41.32     5.77     6.35   8,269        66.99     7.73     0.84     1.39  14,287
                                             1.80-SINK     33.01    73.45    27.57    29.21   2,271       100.00    29.42     9.67    10.57  10,320

  100M BY 325M                              FLOAT-1.30     35.21     1.43     0.12     0.66  15,355        35.21     1.43     0.12     0.66  15,355
  PERCENT OF FLOW  58.1                      1.30-1.35     19.27     3.21     0.33     0.88  14,907        54.47     2.06     0.19     0.74  15,197
                                             1.35-1.40     11.81     4.86     0.49     1.07  13,909        66.29     2.56     0.25     0.80  14,967
                                             1.40-1.50      5.48    12.56     1.31     1.84  12,682        71.77     3.32     0.33     0.88  14,793
                                             1.50-1.60      3.06    21.53     2.34     2.88  11,077        74.82     4.07     0.41     0.96  14,641
                                             1.60-1.70      1.97    29.89     3.77     4.24   9,723        76.80     4.73     0.50     1.05  14,515
                                             1.70-1.80      1.06    38.94     6.24     6.82   8,269        77.85     5.19     0.57     1.12  14,430
                                             1.80-SINK     22.15    69.53    28.83    30.28   2,145       100.00    19.44     6.83     7.58  11,709

  COMPOSITE                                 FLOAT-1.30     36.13     1.61     0.14     0.69  15,355        36.13     1.61     0.14     0.69  15,355
  FLOWRATE               17.4                1.30-1.35     15.61     3.89     0.40     0.94  14,907        51.75     2.30     0.22     0.77  15,220
                                             1.35-1.40      9.20     5.79     0.61     1.17  13,909        60.94     2.83     0.28     0.83  15,022
                                             1.40-1.50      5.22    13.73     1.47     2.02  12,682        66.16     3.69     0.37     0.92  14,837
                                             1.50-1.60      3.38    23.16     2.38     2.89  11,077        69.54     4.63     0.47     1.02  14,655
                                             1.60-1.70      2.44    31.21     3.73     4.25   9,723        71.97     5.53     0.58     1.13  14,488
                                             1.70-1.80      1.33    40.22     5.99     6.57   8,269        73.30     6.16     0.68     1.22  14,375
                                             1.80-SINK     26.70    71.56    28.18    29.73   2,210       100.00    23.62     8.02     8.83  11,128
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                                                                                      USER HANDBOOK EXAMPLE PAGE 36

                          SUMMARY OF THE PERFORMANCE CHARACTERISTICS OF UNIT NUMBER 11

                                          CONCENTRATING TABLE
                                     SPECIFIC GRAVITY OF SEPARATION =1.58

SIZE, INCHES OR MESH                        1/2       8M      28M     100M     COMP
                                             BY       BY       BY       BY
                                             8M      28M     100M     325M

SCREEN ANALYSIS, PERCENT-
   FEED.................................. 44.88    36.62    12.26     6.24   100.00
   CLEAN COAL............................ 51.31    27.37    12.74     6.58   100.00
   REFUSE................................ 34.97    50.89    11.53     2.61   100.00

ASH, PERCENT
   FEED.................................. 24.98    40.54    29.42    19.44    30.88
   CLEAN COAL............................  6.41     6.97     8.21    10.47     7.14
   REFUSE................................ 67.02    68.41    65.62    64.95    67.51

PYRITIC SULFUR, PERCENT
   FEED..................................  7.77    12.99     9.67     6.83     9.85
   CLEAN COAL............................  0.42     0.86     1.44     2.95     0.89
   REFUSE................................ 24.40    23.06    23.69    26.51    23.69

TOTAL SULFUR, PERCENT
   FEED..................................  8.58    14.00    10.57     7.58    10.75
   CLEAN COAL............................  0.98     1.39     2.02     3.58     1.45
   REFUSE................................ 25.79    24.47    25.16    27.88    25.10

BTU/LB, MOISTURE FREE
   FEED.................................. 11,297    8,538   10,320   11,709   10,193
   CLEAN COAL............................ 14,585   14,421   14,200   13,424   14,391
   REFUSE................................  3,853    3,655    3,699    3,015    3,713
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                                                                                                    USER HANDBOOK EXAMPLE PAGE 37
                          SUMMARY OF THE PERFORMANCE CHARACTERISTICS OF UNIT NUMBER 11 (CONTINUED)

                                                    CONCENTRATING TABLE
                                           SPECIFIC GRAVITY OF SEPARATION =1.58

SIZE, INCHES OR MESH                                 1/2        8M       28M      100M      COMP
                                                      BY        BY        BY        BY
                                                      8M       28M      100M      325M

ACTUAL RECOVERY..................... PERCENT       69.4      45.4      63.0      83.5      60.7
THEORETICAL RECOVERY...............     DO         70.5      48.1      67.7      86.1      63.7
RECOVERY EFFICIENCY................     DO         98.4      94.3      93.1      97.1      95.3
BTU RECOVERY.......................     DO         89.6      76.6      86.8      95.8      85.7
ASH ERROR..........................     DO          0.3       1.3       2.3       1.6       1.2
FLOAT IN REFUSE......... PERCENT OF PRODUCT         5.1       4.6      11.8      33.5       5.8
SINK IN CLEAN COAL......        DO                  2.2       6.1       4.6       6.2       5.4
TOTAL MISPLACED MATERIAL... PERCENT OF FEED         3.1       5.3       7.3      10.7       5.1
NEAR GRAVITY 0.1 MATERIAL..     DO                  8.8       9.6       5.3       5.5       8.5
SPECIFIC GRAVITY OF SEPARATION.............        1.55      1.54      1.68      2.02      1.56
PROBABLE ERROR, SPECIFIC GRAVITY...........       0.024     0.075     0.203     0.256     0.066
IMPERFECTION...............................       0.015     0.049     0.121     0.127     0.042
ERROR AREA.................................          40        57       118       168        66
DISTRIBUTION, PERCENT TO WASHED COAL
  (SPECIFIC GRAVITY FRACTION)-
    FLOAT-1.30..............................      100.0      99.5      98.1      99.4      99.5
    1.30-1.35...............................       99.8      98.8      96.2      98.9      99.2
    1.35-1.40...............................       99.2      95.5      93.1      98.3      97.5
    1.40-1.50...............................       93.4      79.8      85.3      97.0      88.7
    1.50-1.60...............................       55.7      46.1      71.0      94.1      55.2
    1.60-1.70...............................       16.2      19.5      54.7      88.5      25.4
    1.70-1.80...............................        3.6       7.5      38.1      76.1      11.8
    SINK-1.80...............................        0.6       1.0       5.6      32.1       2.7
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                                                                                      USER HANDBOOK EXAMPLE PAGE 38

                                     SPECIFIC GRAVITY ANALYSIS OF FLOWSTREAM NUMBER 18

                          ORIGIN - UNIT NUMBER  11   C       DESTINATION - UNIT NUMBER  16

                                SPECIFIC            DIRECT, PERCENT                                      CUMULATIVE, PERCENT
    SIZE FRACTION AND WEIGHT    GRAVITY    WEIGHT    ASH  PYRITIC   TOTAL   BTU/LB      WEIGHT    ASH  PYRITIC   TOTAL   BTU/LB
                                                          SULFUR   SULFUR                                SULFUR   SULFUR

 1/2 BY 8M                     FLOAT-1.30   44.20    2.47    0.10    0.67  15,355        44.20    2.47    0.10    0.67  15,355
 PERCENT OF FLOW  51.3          1.30-1.35   31.07    4.75    0.23    0.81  14,907        75.26    3.41    0.15    0.73  15,170
                                1.35-1.40    9.96    9.58    0.59    1.07  13,909        85.22    4.13    0.20    0.77  15,023
                                1.40-1.50   10.85   15.75    1.02    1.56  12,682        96.07    5.45    0.29    0.86  14,758
                                1.50-1.60    3.08   25.82    1.73    2.16  11,077        99.15    6.08    0.34    0.90  14,644
                                1.60-1.70    0.54   33.65    3.11    3.48   9,723        99.70    6.23    0.35    0.91  14,617
                                1.70-1.80    0.09   42.03    4.53    4.84   8,269        99.78    6.26    0.36    0.92  14,612
                                1.80-SINK    0.22   75.45   29.52   31.15   2,373       100.00    6.41    0.42    0.98  14,585

 8M BY 28M                     FLOAT-1.30   51.26    1.95    0.18    0.68  15,355        51.26    1.95    0.18    0.68  15,355
 PERCENT OF FLOW  27.4          1.30-1.35   24.06    4.44    0.41    0.94  14,907        75.32    2.75    0.25    0.77  15,212
                                1.35-1.40    7.20    9.05    0.88    1.38  13,909        82.52    3.30    0.31    0.82  15,098
                                1.40-1.50    9.47   15.57    1.48    2.03  12,682        91.99    4.56    0.43    0.94  14,850
                                1.50-1.60    4.82   25.58    2.14    2.63  11,077        96.81    5.61    0.52    1.03  14,662
                                1.60-1.70    1.78   33.14    3.52    4.09   9,723        98.59    6.10    0.57    1.08  14,573
                                1.70-1.80    0.39   42.66    5.70    6.22   8,269        98.97    6.25    0.59    1.10  14,548
                                1.80-SINK    1.03   76.51   27.24   28.84   2,250       100.00    6.97    0.86    1.39  14,421

 28M BY 100M                   FLOAT-1.30   58.21    1.86    0.16    0.72  15,355        58.21    1.86    0.16    0.72  15,355
 PERCENT OF FLOW  12.7          1.30-1.35   16.08    3.61    0.53    1.10  14,907        74.30    2.67    0.25    0.80  15,258
                                1.35-1.40    8.21    8.52    0.97    1.45  13,909        82.51    3.25    0.32    0.87  15,124
                                1.40-1.50    6.58   15.56    1.72    2.29  12,682        89.09    4.16    0.43    0.97  14,944
                                1.50-1.60    4.30   24.97    2.42    2.90  11,077        93.39    5.12    0.52    1.06  14,765
                                1.60-1.70    2.67   32.39    3.68    4.27   9,723        96.06    5.88    0.61    1.15  14,625
                                1.70-1.80    1.03   41.32    5.77    6.35   8,269        97.09    6.26    0.66    1.20  14,558
                                1.80-SINK    2.91   73.45   27.57   29.21   2,271       100.00    8.21    1.44    2.02  14,200

 100M BY 325M                  FLOAT-1.30   41.90    1.43    0.12    0.66  15,355        41.90    1.43    0.12    0.66  15,355
 PERCENT OF FLOW   8.6          1.30-1.35   22.82    3.21    0.33    0.88  14,907        64.73    2.06    0.19    0.74  15,197
                                1.35-1.40   13.90    4.86    0.49    1.07  13,909        78.63    2.55    0.25    0.80  14,969
                                1.40-1.50    6.36   12.56    1.31    1.84  12,682        84.99    3.30    0.33    0.88  14,798
                                1.50-1.60    3.45   21.53    2.34    2.88  11,077        88.43    4.01    0.40    0.96  14,653
                                1.60-1.70    2.09   29.89    3.77    4.24   9,723        90.52    4.61    0.48    1.03  14,539
                                1.70-1.80    0.96   38.94    6.24    6.82   8,269        91.48    4.97    0.54    1.09  14,473
                                1.80-SINK    8.52   69.53   28.83   30.28   2,145       100.00   10.47    2.95    3.58  13,424

 COMPOSITE                     FLOAT-1.30   47.72    2.14    0.13    0.68  15,355        47.72    2.14    0.13    0.68  15,355
 FLOWRATE          103.0        1.30-1.35   26.53    4.63    0.31    0.87  14,907        74.25    3.03    0.20    0.75  15,195
                                1.35-1.40    9.32    8.75    0.68    1.18  13,909        83.57    3.67    0.25    0.80  15,052
                                1.40-1.50    9.54   15.50    1.22    1.77  12,682        93.11    4.88    0.35    0.90  14,809
                                1.50-1.60    3.74   25.27    2.02    2.49  11,077        96.85    5.67    0.41    0.96  14,664
                                1.60-1.70    1.29   32.60    3.51    4.03   9,723        98.14    6.02    0.45    1.00  14,600
                                1.70-1.80    0.36   41.25    5.71    6.24   8,269        98.50    6.15    0.47    1.02  14,576
                                1.80-SINK    1.50   72.26   28.27   29.81   2,213       100.00    7.14    0.89    1.45  14,391
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                                        SPECIFIC GRAVITY ANALYSIS OF FLOWSTREAM NUMBER 19

                              ORIGIN - UNIT NUMBER  11   R       DESTINATION - UNIT NUMBER  12

                                    SPECIFIC              DIRECT, PERCENT                                        CUMULATIVE, PERCENT
     SIZE FRACTION AND WEIGHT       GRAVITY      WEIGHT     ASH  PYRITIC   TOTAL  BTU/LB        WEIGHT     ASH  PYRITIC   TOTAL  BTU/LB
                                                                  SULFUR  SULFUR                                 SULFUR  SULFUR

1/2 BY 8M                          FLOAT-1.30      0.00    0.00     0.00    0.00       0          0.00    0.00     0.00    0.00       0
PERCENT OF FLOW  35.0               1.30-1.35      0.16    4.75     0.23    0.81  14,907          0.16    4.75     0.23    0.81  14,907
                                    1.35-1.40      0.19    9.58     0.59    1.07  13,909          0.35    7.40     0.42    0.95  14,360
                                    1.40-1.50      1.75   15.75     1.02    1.56  12,682          2.09   14.36     0.92    1.46  12,960
                                    1.50-1.60      5.55   25.82     1.73    2.16  11,077          7.65   22.69     1.51    1.96  11,593
                                    1.60-1.70      6.39   33.65     3.11    3.48   9,723         14.04   27.68     2.24    2.65  10,741
                                    1.70-1.80      5.18   42.03     4.53    4.84   8,269         19.22   31.54     2.86    3.24  10,075
                                    1.80-SINK     80.78   75.45    29.52   31.15   2,373        100.00   67.02    24.40   25.79   3,853

8M BY 28M                          FLOAT-1.30      0.21    1.95     0.18    0.68  15,355          0.21    1.95     0.18    0.68  15,355
PERCENT OF FLOW  50.9               1.30-1.35      0.25    4.44     0.41    0.94  14,907          0.46    3.30     0.31    0.82  15,112
                                    1.35-1.40      0.28    9.05     0.88    1.38  13,909          0.74    5.51     0.53    1.04  14,651
                                    1.40-1.50      1.99   15.57     1.48    2.03  12,682          2.73   12.85     1.22    1.76  13,215
                                    1.50-1.60      4.67   25.58     2.14    2.63  11,077          7.40   20.88     1.80    2.31  11,865
                                    1.60-1.70      6.11   33.14     3.52    4.09   9,723         13.51   26.43     2.58    3.11  10,897
                                    1.70-1.80      3.93   42.66     5.70    6.22   8,269         17.44   30.09     3.28    3.82  10,304
                                    1.80-SINK     82.56   76.51    27.24   28.84   2,250        100.00   68.41    23.06   24.47   3,655

28M BY 100M                        FLOAT-1.30      1.92    1.86     0.16    0.72  15,355          1.92    1.86     0.16    0.72  15,355
PERCENT OF FLOW  11.5               1.30-1.35      1.09    5.61     0.58    1.10  14,907          3.01    3.21     0.31    0.86  15,193
                                    1.35-1.40      1.03    8.52     0.97    1.45  13,909          4.04    4.57     0.48    1.01  14,865
                                    1.40-1.50      1.94   15.56     1.72    2.29  12,682          5.98    8.13     0.88    1.42  14,158
                                    1.50-1.60      2.99   24.97     2.42    2.90  11,077          8.97   13.75     1.40    1.92  13,130
                                    1.60-1.70      3.78   32.39     3.68    4.27   9,723         12.75   19.27     2.07    2.61  12,120
                                    1.70-1.80      2.87   41.32     5.77    6.35   8,269         15.62   23.33     2.75    3.30  11,412
                                    1.80-SINK     84.38   73.45    27.57   29.21   2,271        100.00   65.62    23.69   25.16   3,699

100M BY 325M                       FLOAT-1.30      1.25    1.43     0.12    0.66  15,355          1.25    1.43     0.12    0.66  15,355
PERCENT OF FLOW   2.6               1.30-1.35      1.23    3.21     0.33    0.88  14,907          2.49    2.31     0.22    0.77  15,133
                                    1.35-1.40      1.24    4.86     0.49    1.07  13,909          3.72    3.16     0.31    0.87  14,726
                                    1.40-1.50      0.99   12.56     1.31    1.84  12,682          4.72    5.14     0.52    1.08  14,296
                                    1.50-1.60      1.09   21.53     2.34    2.88  11,077          5.81    8.23     0.86    1.42  13,689
                                    1.60-1.70      1.38   29.89     3.77    4.24   9,723          7.19   12.39     1.42    1.96  12,928
                                    1.70-1.80      1.54   38.94     6.24    6.82   8,269          8.73   17.06     2.27    2.81  12,107
                                    1.80-SINK     91.27   69.53    28.83   30.28   2,145        100.00   64.95    26.51   27.88   3,015

COMPCSITE                          FLOAT-1.30      0.36    1.85     0.16    0.70  15,355          0.36    1.85     0.16    0.70  15,355
FLOWRATE            66.7            1.30-1.35      0.34    4.81     0.44    0.97  14,907          0.70    3.28     0.30    0.83  15,138
                                    1.35-1.40      0.36    8.60     0.82    1.32  13,909          1.06    5.10     0.48    1.00  14,719
                                    1.40-1.50      1.87   15.59     1.36    1.90  12,682          2.93   11.79     1.04    1.58  13,418
                                    1.50-1.60      4.69   25.61     1.99    2.45  11,077          7.63   20.30     1.62    2.12  11,977
                                    1.60-1.70      5.82   33.26     3.38    3.87   9,723         13.44   25.90     2.38    2.88  11,002
                                    1.70-1.80      4.18   42.25     5.20    5.64   8,269         17.63   29.78     3.05    3.53  10,353
                                    1.80-SINK     82.37   75.58    28.11   29.72   2,292        100.00   67.51    23.69   25.10   3,713
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                                              SUMMARY OF THE PERFORMANCE CHARACTERISTICS OF UNIT NUMBER 12

                                                                  STREAM BLENDER

SIZE, INCHES OR MESH                                 18        12         6         2       1/2        8M       28M      100M      COMP
                                                     BY        BY        BY        BY        BY        BY        BY        BY
                                                     12         6         2       1/2        8M       28M      100M      325M

SCREEN ANALYSIS, PERCENT-
   PRODUCT...................................      7.08     23.46     29.40      9.32     10.87     15.55      3.52      0.80    100.00
   FEED 1....................................     10.19     33.78     42.33     13.42      0.27      0.00      0.00      0.00    100.00
   FEED 2....................................      0.00      0.00      0.00      0.00     34.97     50.89     11.53      2.61    100.00

ASH, PERCENT
   PRODUCT...................................     97.73     94.55     74.98     65.67     67.10     68.41     65.62     64.95     78.03
   FEED 1....................................     97.73     94.55     74 98     65.67     72.01     45.85     50.40     48.13     82.65
   FEED 2....................................      0.00      0.00      0.00      0.00     67.02     68.41     65.62     64.95     67.51

PYRITIC SULFUR, PERCENT
   PRODUCT...................................      0.43      0.97     22.63     29.54     24.46     23.06     23.69     26.51     16.95
   FEED 1....................................      0.43      0.97     22.63     29.54     28.13     16.07     21.69     22.90     13.99
   FEED 2....................................      0.00      0.00      0.00      0.00     24.40     23.06     23.69     26.51     23.69

TOTAL SULFUR, PERCENT
   PRODUCT...................................      0.46      1.05     23.78     32.12     25.86     24.47     25.16     27.88     17.99
   FEED 1....................................      0.46      1.05     23.78     32.12     29.67     17.02     22.89     23.92     14.86
   FEED 2....................................      0.00      0.00      0.00      0.00     25.79     24.47     25.16     27.88     25.10

BTU/LB, MOISTURE FREE
   PRODUCT...................................       332       793     2,765     3,600     3,837     3,655     3,699     3,015     2,498
   FEED 1....................................       332       793     2,765     3,600     2,961     7,540     5,271     5,080     1,963
   FEED 2....................................         0         0         0         0     3,853     3,655     3,699     3,015     3,713
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                                   SPECIFIC GRAVITY ANALYSIS OF FLOWSTREAM NUMBER 20

                         ORIGIN - UNIT NUMBER  12   R         DESTINATION - UNIT NUMBER  14

                                  SPECIFIC               DIRECT, PERCENT                                      CUMULATIVE, PERCENT
     SIZE FRACTION AND WEIGHT     GRAVITY     WEIGHT     ASH   PYRITIC   TOTAL   BTU/LB        WEIGHT     ASH   PYRITIC   TOTAL   BTU/LB
                                                                SULFUR   SULFUR                                   SULFUR   SULFUR

 18 BY 12                        FLOAT-1.30     0.85     2.80     0.21     0.79   15,355          0.85     2.80     0.21     0.79   15,355
 PERCENT OF FLOW    7.1            1.30-1.35    0.48     4.40     0.71     1.57   14,907          1.33     3.37     0.39     1.07   15,194
                                   1.35-1.40    0.09     7.80     0.93     1.59   13,909          1.42     3.66     0.43     1.10   15,112
                                   1.40-1.50    0.49    15.40     1.10     1.60   12,682          1.91     6.67     0.60     1.23   14,489
                                   1.50-1.60    0.09    25.00     1.44     1.84   11,077          2.00     7.50     0.64     1.26   14,334
                                   1.60-1.70    0.08    31.50     2.90     3.50    9,723          2.08     8.45     0.73     1.35   14,152
                                   1.70-1.80    0.03    41.00     5.46     6.13    8,269          2.11     8.98     0.80     1.43   14,055
                                   1.80-SINK   97.89    99.65     0.42     0.44       35        100.00    97.73     0.43     0.46      332

 12 BY 6                         FLOAT-1.30     1.82     2.87     0.19     0.80   15,355          1.82     2.87     0.19     0.80   15,355
 PERCENT OF FLOW   23.5            1.30-1.35    1.38     4.63     0.64     1.31   14,907          3.20     3.62     0.38     1.02   15,162
                                   1.35-1.40    0.45     9.17     1.04     1.64   13,909          3.64     4.31     0.47     1.09   15,008
                                   1.40-1.50    0.73    16.08     1.32     1.85   12,682          4.38     6.28     0.61     1.22   14,618
                                   1.50-1.60    0.36    26.39     1.87     2.36   11,077          4.74     7.82     0.71     1.31   14,347
                                   1.60-1.70    0.21    34.09     3.14     3.70    9,723          4.95     8.94     0.81     1.41   14,150
                                   1.70-1.80    0.11    44.65     5.93     6.46    8,269          5.07     9.73     0.92     1.52   14,020
                                   1.80-SINK   94.93    99.08     0.97     1.03       87        100.00    94.55     0.97     1.05      793

 6 BY 2                          FLOAT-1.30     0.00     0.00     0.00     0.00        0          0.00     0.00     0.00     0.00        0
 PERCENT OF FLOW   29.4            1.30-1.35    0.00     0.00     0.00     0.00        0          0.00     0.00     0.00     0.00        0
                                   1.35-1.40    0.00     0.00     0.00     0.00        0          0.00     0.00     0.00     0.00        0
                                   1.40-1.50    2.61    15.54     1.74     2.33   12,682          2.61    15.54     1.74     2.33   12,682
                                   1.50-1.60    2.00    25.78     2.24     2.77   11,077          4.60    19.97     1.96     2.52   11,986
                                   1.60-1.70    2.58    32.75     3.63     4.24    9,723          7.18    24.56     2.56     3.14   11,174
                                   1.70-1.80    1.46    42.99     5.76     6.40    8,269          8.64    27.68     3.10     3.69   10,682
                                   1.80-SINK   91.36    79.45    24.47    25.68    2,016        100.00    74.98    22.63    23.78    2,765

 2 BY 1/2                        FLOAT-1.30     0.00     0.00     0.00     0.00        0          0.00     0.00     0.00     0.00        0
 PERCENT OF FLOW    9.3            1.30-1.35    0.09     4.64     0.55     1.12   14,907          0.09     4.64     0.55     1.12   14,907
                                   1.35-1.40    0.08     9.35     1.00     1.51   13,909          0.18     6.85     0.76     1.30   14,439
                                   1.40-1.50    0.62    15.92     1.52     2.08   12,682          0.79    13.88     1.35     1.91   13,076
                                   1.50-1.60    3.21    26.02     2.06     2.52   11,077          4.00    23.61     1.92     2.40   11,474
                                   1.60-1.70    3.41    33.81     3.46     3.98    9,723          7.41    28.30     2.63     3.13   10,668
                                   1.70-1.80    3.29    43.01     5.69     6.21    8,269         10.70    32.82     3.57     4.08    9,931
                                   1.80-SINK   89.30    69.61    32.65    35.48    2,841        100.00    65.67    29.54    32.12    3,600

 1/2 BY 8M                       FLOAT-1.30     0.00     2.47     0.10     0.67   15,355          0.00     2.47     0.10     0.67   15,355
 PERCENT OF FLOW   10.9            1.30-1.35    0.16     4.75     0.23     0.81   14,907          0.17     4.71     0.22     0.81   14,916
                                   1.35-1.40    0.19     9.58     0.59     1.07   13,909          0.36     7.33     0.42     0.95   14,376
                                   1.40-1.50    1.72    15.75     1.02     1.56   12,682          2.08    14.28     0.91     1.45   12,976
                                   1.50-1.60    5.48    25.82     1.73     2.16   11,077          7.57    22.65     1.51     1.96   11,599
                                   1.60-1.70    6.31    33.65     3.11     3.48    9,723         13.88    27.65     2.24     2.65   10,746
                                   1.70-1.80    5.13    42.03     4.53     4.83    8,269         19.01    31.53     2.86     3.24   10,078
                                   1.80-SINK   80.99    75.45    29.53    31.16    2,373        100.00    67.10    24.46    25.86    3,837
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                                                                                                USER HANDBOOK EXAMPLE PAGE 42

                                     SPECIFIC GRAVITY ANALYSIS OF FLOWSTREAM NUMBER 20 (CONTINUED)

                                  ORIGIN - UNIT NUMBER  12   R        JESTINATION - UNIT NUMBER  14

                                     SPECIFIC              DIRECT. PERCENT                                    CUMULATIVE. PERCENT
     SIZE FRACTION AND WEIGHT        GRAVITY    WEIGHT    ASH  PYRITIC   TOTAL   BTU/LB       WEIGHT    ASH  PYRITIC   TOTAL   BTU/LB
                                                               SULFUR  SULFUR                                  SULFUR  SULFUR

  8M BY 28M                        FLOAT-1.30    0.21    1.95    0.18    0.68   15,355        0.21    1.95    0.18    0.68  15,355
  PERCENT OF FLOW  15.5             1.30-1.35    0.25    4.44    0.41    0.94   14,907        0.46    3.30    0.31    0.82  15,112
                                    1.35-1.40    0.28    9.05    0.88    1.38   13,909        0.74    5.51    0.53    1.04  14,651
                                    1.40-1.50    1.99   15.57    1.48    2.03   12,682        2.73   12.84    1.22    1.76  13,215
                                    1.50-1.60    4.67   25.58    2.14    2.63   11,077        7.40   20.88    1.80    2.31  11,866
                                    1.60-1.70    6.11   33.14    3.52    4.09    9,723       13.51   26.42    2.58    3.11  10,897
                                    1.70-1.80    3.93   42.66    5.70    6.22    8,269       17.44   30.09    3.28    3.81  10,304
                                    1.80-SINK   82.56   76.51   27.24   28.84    2,250      100.00   68.41   23.06   24.47   3,655

  28M BY 100M                      FLOAT-1.30    1.92    1.86    0.16    0.72   15,355        1.92    1.86    0.16    0.72  15,355
  PERCENT OF FLOW   3.5             1.30-1.35    1.09    5.61    0.58    1.10   14,907        3.01    3.21    0.31    0.86  15,193
                                    1.35-1.40    1.03    8.52    0.97    1.45   13,909        4.04    4.57    0.48    1.01  14,865
                                    1.40-1.50    1.94   15.56    1.72    2.29   12,682        5.98    8.13    0.88    1.42  14,158
                                    1.50-1.60    2.99   24.97    2.42    2.90   11,077        8.97   13.75    1.40    1.92  13,130
                                    1.60-1.70    3.78   32.39    3.68    4.27    9,723       12.75   19.27    2.07    2.61  12,121
                                    1.70-1.80    2.87   41.32    5.77    6.35    8,269       15.62   23.33    2.75    3.30  11,412
                                    1.80-SINK   84.38   73.45   27.57   29.21    2,271      100.00   65.62   23.69   25.16   3,699

  100M BY 325M                     FLOAT-1.30    1.25    1.43    0.12    0.66   15,355        1.25    1.43    0.12    0.66  15,355
  PERCENT OF FLOW   0.8             1.30-1.35    1.23    3.21    0.33    0.88   14,907        2.49    2.31    0.22    0.77  15,133
                                    1.35-1.40    1.24    4.86    0.49    1.07   13,909        3.73    3.16    0.31    0.87  14,726
                                    1.40-1.50    0.99   12.56    1.31    1.84   12,682        4.72    5.14    0.52    1.08  14,296
                                    1.50-1.60    1.09   21.53    2.34    2.88   11,077        5.81    8.22    0.86    1.42  13,690
                                    1.60-1.70    1.38   29.89    3.77    4.24    9,723        7.19   12.38    1.42    1.96  12,928
                                    1.70-1.80    1.54   38.94    6.24    6.82    8,269        8.73   17.06    2.27    2.81  12,107
                                    1.80-SINK   91.27   69.53   28.83   30.28    2,145      100.00   64.95   26.51   27.88   3,015

  COMPOSITE                        FLOAT-1.30    0.60    2.67    0.19    0.78   15,355        0.60    2.67    0.19    0.78  15,355
  FLOWRATE           218.4          1.30-1.35    0.47    4.65    0.60    1.25   14,907        1.07    3.54    0.37    0.99  15,158
                                    1.35-1.40    0.23    8.87    0.93    1.48   13,909        1.30    4.49    0.47    1.07  14,936
                                    1.40-1.50    1.60   15.62    1.54    2.10   12,682        2.90   10.64    1.06    1.64  13,690
                                    1.50-1.60    2.41   25.73    2.06    2.53   11,077        5.32   17.49    1.51    2.05  12,504
                                    1.60-1.70    2.91   33.20    3.45    3.98    9,723        8.23   23.05    2.20    2.73  11,520
                                    1.70-1.80    2.05   42.55    5.40    5.89    8,269       10.28   26.94    2.84    3.36  10,872
                                    1.80-SINK   89.72   83.88   18.57   19.67    1,539      100.00   78.03   16.95   17.99   2,498
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                                                                                              USER HANDBOOK EXAMPLE PAGE 43
                                       SUMMARY OF THE PERFORMANCE CHARACTERISTICS OF UNIT NUMBER 13

                                                              FROTH FLOTATION CELL

SIZE, INCHES OR MESH                            28M      100M      COMP
                                                 BY        BY
                                               100M      325M

SCREEN ANALYSIS, PERCENT-
   FEED..................................... 41.86     58.14    100.00
   CLEAN COAL............................... 37.05     62.95    100.00
   REFUSE................................... 51.09     48.91    100.00

ASH, PERCENT
   FEED..................................... 29.42     19.44     23.62
   CLEAN COAL...............................  5.62      4.15      4.70
   REFUSE................................... 62.56     57.22     59.95

PYRITIC SULFUR, PERCENT
   FEED.....................................  9.67      6.83      8.02
   CLEAN COAL...............................  0.78      0.56      0.64
   REFUSE................................... 22.04     22.32     22.18

TOTAL SULFUR, PERCENT
   FEED..................................... 10.57      7.58      8.83
   CLEAN COAL...............................  1.33      1.12      1.20
   REFUSE................................... 23.43     23.55     23.49

BTU/LB, MOISTURE FREE
   FEED.....................................10,320    11,709    11,128
   CLEAN COAL...............................14,678    14,642    14,655
   REFUSE...................................  4,252     4,463     4,355
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            SUMMARY OF THE PERFORMANCE CHARACTERISTICS OF UNIT NUMBER 13 (CONTINUED)

                                         FROTH FLOTATION CELL

SIZE, INCHES OR MESH                          28M       100M      COMP
                                               BY        BY
                                              100M      325M

ACTUAL RECOVERY...................... PERCENT  58.2      71.2      65.7
THEORETICAL RECOVERY...............      DO    62.3      75.1      69.7
RECOVERY EFFICIENCY................      DO    93.4      94.8      94.3
BTU RECOVERY.......................      DO    82.8      89.0      86.6
ASH ERROR..........................      DO     1.4       0.9       1.1
FLOAT IN REFUSE.......... PERCENT OF PRODUCT    8.0      12.5      10.3
SINK IN CLEAN COAL......          DO            4.6       2.7       2.3
TOTAL MISPLACED MATERIAL... PERCENT OF FEED     6.0       5.5       5.8
NEAR GRAVITY 0.1 MATERIAL..       DO            8.4       7.3       7.9
SPECIFIC GRAVITY OF SEPARATION..............   1.51      1.54      1.53
PROBABLE ERROR, SPECIFIC GRAVITY............  0.086     0.093     0.088
IMPERFECTION................................  0.057     0.060     0.058
ERROR AREA..................................     70        72        70
DISTRIBUTION, PERCENT TO WASHED COAL
  (SPECIFIC GRAVITY FRACTION)-
    FLOAT-1.30...............................   98.6      99.2      98.9
    1.30-1.35................................   96.1      97.3      97.0
    1.35-1.40................................   89.0      92.6      91.7
    1.40-1.50................................   69.4      75.6      73.2
    1.50-1.60................................   39.9      45.8      43.0
    1.60-1.70................................   19.3      23.2      21.1
    1.70-1.80................................   10.5      12.1      11.3
    SINK-1.80................................    1.8       2.0       1.9
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                                      SPECIFIC GRAVITY ANALYSIS OF FLOWSTREAM NUMBER 21

                              ORIGIN - UNIT NUMBER  13   C        DESTINATION - UNIT NUMBER  16

                                    SPECIFIC              DIRECT, PERCENT                                 CUMULATIVE, PERCENT
   SIZE FRACTION AND WEIGHT         GRAVITY     WEIGHT     ASH  PYRITIC   TOTAL   BTU/LB       WEIGHT     ASH  PYRITIC   TOTAL   BTU/LB
                                                                SULFUR   SULFUR                                SULFUR   SULFUR

28M BY 100M                        FLOAT-1.30    63.37     1.86     0.16     0.72  15,355        63.37     1.86     0.16     0.72  15,355
PERCENT OF FLOW  37.1               1.30-1.35    17.40     5.61     0.58     1.10  14,907        80.77     2.67     0.25     0.80  15,258
                                    1.35-1.40     8.50     8.52     0.97     1.45  13,909        89.26     3.22     0.32     0.86  15,130
                                    1.40-1.50     5.80    15.56     1.72     2.29  12,682        95.06     3.96     0.40     0.95  14,981
                                    1.50-1.60     2.62    24.97     2.42     2.90  11,077        97.68     4.54     0.46     1.00  14,876
                                    1.60-1.70     1.02    32.39     3.68     4.27   9,723        98.70     4.83     0.49     1.04  14,823
                                    1.70-1.80     0.31    41.32     5.77     6.35   8,269        99.01     4.94     0.51     1.05  14,802
                                    1.80-SINK     0.99    73.45    27.57    29.21   2,271       100.00     5.62     0.78     1.33  14,678

100M BY 325M                       FLOAT-1.30    49.05     1.43     0.12     0.66  15,355        49.05     1.43     0.12     0.66  15,355
PERCENT OF FLOW  62.9               1.30-1.35    26.35     3.21     0.33     0.88  14,907        75.39     2.05     0.19     0.74  15,198
                                    1.35-1.40    15.37     4.86     0.49     1.07  13,909        90.76     2.53     0.24     0.80  14,980
                                    1.40-1.50     5.82    12.56     1.31     1.84  12,682        96.57     3.13     0.31     0.86  14,842
                                    1.50-1.60     1.97    21.53     2.34     2.88  11,077        98.54     3.50     0.35     0.90  14,767
                                    1.60-1.70     0.64    29.89     3.77     4.24   9,723        99.19     3.67     0.37     0.92  14,734
                                    1.70-1.80     0.18    38.94     6.24     6.82   8,269        99.36     3.73     0.38     0.93  14,722
                                    1.80-SINK     0.64    69.53    28.83    30.28   2,145       100.00     4.15     0.56     1.12  14,642

COMPOSITE                          FLOAT-1.30    54.35     1.61     0.14     0.69  15,355        54.35     1.61     0.14     0.69  15,355
FLOWRATE             11.4           1.30-1.35    23.03     3.88     0.40     0.94  14,907        77.38     2.29     0.22     0.76  15,222
                                    1.35-1.40    12.82     5.76     0.61     1.16  13,909        90.20     2.78     0.27     0.82  15,035
                                    1.40-1.50     5.81    13.67     1.46     2.01  12,682        96.01     3.44     0.34     0.89  14,893
                                    1.50-1.60     2.21    23.04     2.38     2.89  11,077        98.22     3.88     0.39     0.94  14,807
                                    1.60-1.70     0.78    31.10     3.73     4.25   9,723        99.00     4.10     0.42     0.96  14,767
                                    1.70-1.80     0.23    40.14     6.01     6.58   8,269        99.23     4.18     0.43     0.98  14,752
                                    1.80-SINK     0.77    71.41    28.23    29.77   2,205       100.00     4.70     0.64     1.20  14,655
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                                                                                              USER HANDBOOK EXAMPLE PAGE 46

                                     SPECIFIC GRAVITY ANALYSIS OF FLOWSTREAM NUMBER 22

                              ORIGIN - UNIT NUMBEK  13   R        DESTINATION - UNIT NUMBER  14

                                  SPECIFIC             DIRECT, PERCENT                                  CUMULATIVE, PERCENT
    SIZE FRACTION AND WEIGHT      GRAVITY    WEIGHT     ASH  PYRITIC   TOTAL  BTU/LB       WEIGHT      ASH  PYRITIC   TOTAL  BTU/LB
                                                                SULFUR  SULFUR                                SULFUR  SULFUR

 28M BY 100M                     FLOAT-1.30    1.28    1.86     0.16    0.72  15,355         1.28     1.86     0.16    0.72  15,355
 PERCENT OF FLOW  51.1            1.30-1.35    0.99    5.61     0.58    1.10  14,907         2.27     3.50     0.34    0.89  15,159
                                  1.35-1.40    1.47    8.52     0.97    1.45  13,909         3.74     5.47     0.59    1.11  14,668
                                  1.40-1.50    3.56   15.56     1.72    2.29  12,682         7.30    10.39     1.14    1.68  13,700
                                  1.50-1.60    5.49   24.97     2.42    2.90  11,077        12.79    16.65     1.69    2.21  12,574
                                  1.60-1.70    5.95   32.39     3.68    4.27   9,723        18.74    21.64     2.32    2.86  11,669
                                  1.70-1.80    3.67   41.32     5.77    6.35   8,269        22.41    24.86     2.89    3.43  11,113
                                  1.80-SINK   77.59   73.45    27.57   29.21   2,271       100.00    62.56    22.04   23.43   4,252

 100M BY 325M                    FLOAT-1.30    1.02    1.43     0.12    0.66  15,355         1.02     1.43     0.12    0.66  15,355
 PERCENT OF FLOW  48.9            1.30-1.35    1.78    3.21     0.33    0.88  14,907         2.80     2.56     0.25    0.80  15,070
                                  1.35-1.40    3.04    4.86     0.49    1.07  13,909         5.84     3.76     0.38    0.94  14,465
                                  1.40-1.50    4.64   12.56     1.31    1.84  12,682        10.48     7.66     0.79    1.34  13,676
                                  1.50-1.60    5.75   21.53     2.34    2.88  11,077        16.23    12.57     1.34    1.89  12,755
                                  1.60-1.70    5.26   29.89     3.77    4.24   9,723        21.48    16.81     1.94    2.46  12,013
                                  1.70-1.80    3.23   38.94     6.24    6.82   8,269        24.71    19.70     2.50    3.03  11,524
                                  1.80-SINK   75.29   69.53    28.83   30.28   2,145       100.00    57.22    22.32   23.55   4,463

 COMPOSITE                       FLOAT-1.30    1.15    1.67     0.14    0.70  15,355         1.15     1.67     0.14    0.70  15,355
 FLOWRATE             6.0         1.30-1.35    1.38    4.09     0.42    0.96  14,907         2.53     2.99     0.29    0.84  15,111
                                  1.35-1.40    2.24    6.09     0.65    1.20  13,909         4.77     4.45     0.46    1.01  14,546
                                  1.40-1.50    4.09   13.90     1.49    2.04  12,682         8.85     8.81     0.94    1.49  13,686
                                  1.50-1.60    5.62   23.25     2.38    2.89  11,077        14.47    14.41     1.50    2.03  12,673
                                  1.60-1.70    5.61   31.25     3.73    4.25   9,723        20.08    19.12     2.12    2.65  11,849
                                  1.70-1.80    3.45   40.23     5.99    6.57   8,269        23.54    22.21     2.69    3.23  11,324
                                  1.80-SINK   76.46   71.56    28.18   29.73   2,210       100.00    59.95    22.18   23.49   4,355
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                                                                                                        USER HANDBOOK EXAMPLE PAGE 47

                                       SUMMARY OF THE PERFORMANCE CHARACTERISTICS OF UNIT NUMBER 14

                                                          STREAM BLENDER

SIZE, INCHES OR MESH                           18        12         6         2       1/2        8M       28M      100M      COMP
                                               BY        BY        BY        BY        BY        BY        BY        BY
                                               12         6         2       1/2        8M       28M      100M      325M

SCREEN ANALYSIS, PERCENT-
    PRODUCT................................  6.99     22.83     28.62      9.07     10.58     15.14      4.78      2.08    100.00
    FEED 1.................................  7.08     23.46     29.40      9.32     10.87     15.55      3.52      0.80    100.00
    FEED 2.................................  0.00      0.00      0.00      0.00      0.00      0.00     51.09     48.91    100.00

ASH, PERCENT
    PRODUCT................................ 97.73     94.55     74.98     65.67     67.10     68.41     64.75     60.11     77.55
    FEED 1................................. 97.73     94.55     74.98     65.67     67.10     68.41     65.62     64.95     78.03
    FEED 2.................................  0.00      0.00      0.00      0.00      0.00      0.00     62.56     57.22     59.95

PYRITIC SULFUR, PERCENT
    PRODUCT................................  0.43      0.97     22.63     29.54     24.46     23.06     23.22     23.89     17.09
    FEED 1.................................  0.43      0.97     22.63     29.54     24.46     23.06     23.69     26.51     16.95
    FEED 2.................................  0.00      0.00      0.00      0.00      0.00      0.00     22.04     22.32     22.18

TOTAL SULFUR, PERCENT
    PRODUCT................................  0.46      1.05     23.78     32.12     25.86     24.47     24.67     25.17     18.14
    FEED 1.................................  0.46      1.05     23.78     32.12     25.86     24.47     25.16     27.88     17.99
    FEED 2.................................  0.00      0.00      0.00      0.00      0.00      0.00     23.43     23.55     23.49

BTU/LB, MOISTURE FREE
    PRODUCT................................   332       793     2,765     3,600     3,837     3,655     3,856     3,921     2,547
    FEED 1.................................   332       793     2,765     3,600     3,837     3,655     3,699     3,015     2,498
    FEED 2.................................     0         0         0         0         0         0     4,252     4,463     4,355
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                        SPECIFIC GRAVITY ANALYSIS OF FLOWSTREAM NUMBER 23

                ORIGIN - UNIT NUMBER  14   R        DESTINATION - UNIT NUMBER  15

                                     SPECIFIC             DIRECT, PERCENT                                          CUMULATIVE, PERCENT
      SIZE FRACTION AND WEIGHT        GRAVITY     WEIGHT     ASH  PYRITIC   TOTAL   BTU/LB       WEIGHT     ASH  PYRITIC   TOTAL   BTU/LB
                                                                  SULFUR   SULFUR                               SULFUR   SULFUR

    18 BY 12                        FLOAT-1.30     0.85     2.80    0.21     0.79  15,355          0.85    2.80    0.21     0.79  15,355
    PERCENT OF FLOW    6.9            1.30-1.35     0.48     4.40    0.71     1.57  14,907          1.33    3.37    0.39     1.07  15,194
                                      1.35-1.40     0.09     7.80    0.98     1.59  13,909          1.42    3.66    0.43     1.10  15,112
                                      1.40-1.50     0.49    15.40    1.10     1.60  12,682          1.91    6.67    0.60     1.23  14,489
                                      1.50-1.60     0.09    25.00    1.44     1.84  11,077          2.00    7.50    0.64     1.26  14,334
                                      1.60-1.70     0.08    31.50    2.90     3.50   9,723          2.08    8.45    0.73     1.35  14,152
                                      1.70-1.80     0.03    41.00    5.46     6.13   8,269          2.11    8.98    0.80     1.43  14,055
                                      1.80-SINK    97.89    99.65    0.42     0.44      35        100.00   97.73    0.43     0.46     332

    12 BY 6                         FLOAT-1.30     1.82     2.87    0.19     0.80  15,355          1.82    2.87    0.19     0.80  15,355
    PERCENT OF FLOW   22.8            1.30-1.35     1.38     4.63    0.64     1.31  14,907          3.20    3.62    0.38     1.02  15,162
                                      1.35-1.40     0.45     9.17    1.04     1.64  13,909          3.64    4.31    0.47     1.09  15,008
                                      1.40-1.50     0.73    16.08    1.32     1.85  12,682          4.38    6.28    0.61     1.22  14,618
                                      1.50-1.60     0.36    26.39    1.87     2.36  11,077          4.74    7.82    0.71     1.31  14,347
                                      1.60-1.70     0.21    34.09    3.14     3.70   9,723          4.95    8.94    0.81     1.41  14,150
                                      1.70-1.80     0.11    44.65    5.93     6.46   8,269          5.07    9.73    0.92     1.52  14,020
                                      1.80-SINK    94.93    99.08    0.97     1.03      87        100.00   94.55    0.97     1.05     793

    6 BY 2                          FLOAT-1.30     0.00     0.00    0.00     0.00       0          0.00    0.00    0.00     0.00       0
    PERCENT OF FLOW   28.6            1.30-1.35     0.00     0.00    0.00     0.00       0          0.00    0.00    0.00     0.00       0
                                      1.35-1.40     0.00     0.00    0.00     0.00       0          0.00    0.00    0.00     0.00       0
                                      1.40-1.50     2.61    15.54    1.74     2.33  12,682          2.61   15.54    1.74     2.33  12,682
                                      1.50-1.60     2.00    25.78    2.24     2.77  11,077          4.60   19.97    1.96     2.52  11,986
                                      1.60-1.70     2.58    32.75    3.63     4.24   9,723          7.18   24.56    2.56     3.14  11,174
                                      1.70-1.80     1.46    42.99    5.76     6.40   8,269          8.64   27.68    3.10     3.69  10,682
                                      1.80-SINK    91.36    79.45   24.47    25.68   2,016        100.00   74.98   22.63    23.78   2,765

    2 BY 1/2                        FLOAT-1.30     0.00     0.00    0.00     0.00       0          0.00    0.00    0.00     0.00       0
    PERCENT OF FLOW    9.1            1.30-1.35     0.09     4.64    0.55     1.12  14,907          0.09    4.64    0.55     1.12  14,907
                                      1.35-1.40     0.08     9.35    1.00     1.51  13,909          0.18    6.85    0.76     1.30  14,439
                                      1.40-1.50     0.62    15.92    1.52     2.08  12,682          0.79   13.88    1.35     1.91  13,076
                                      1.50-1.60     3.21    26.02    2.06     2.52  11,077          4.00   23.61    1.92     2.40  11,474
                                      1.60-1.70     3.41    33.81    3.46     3.98   9,723          7.41   28.30    2.63     3.13  10,668
                                      1.70-1.80     3.29    43.01    5.69     6.21   8,269         10.70   32.82    3.57     4.08   9,931
                                      1.80-SINK    89.30    69.61   32.65    35.48   2,841        100.00   65.67   29.54    32.12   3,600

    1/2 BY 0M                       FLOAT-1.30     0.00     2.47    0.10     0.67  15,355          0.00    2.47    0.10     0.67  15,355
    PERCENT OF FLOW   10.6            1.30-1.35     0.16     4.75    0.23     0.81  14,907          0.17    4.71    0.22     0.81  14,916
                                      1.35-1.40     0.19     9.58    0.59     1.07  13,909          0.36    7.33    0.42     0.95  14,376
                                      1.40-1.50     1.72    15.75    1.02     1.56  12,682          2.08   14.28    0.91     1.45  12,976
                                      1.50-1.60     5.48    25.82    1.73     2.16  11,077          7.57   22.65    1.51     1.96  11,599
                                      1.60-1.70     6.31    33.65    3.11     3.48   9,723         13.88   27.65    2.24     2.65  10,746
                                      1.70-1.80     5.13    42.03    4.53     4.83   8,269         19.01   31.53    2.86     3.24  10,078
                                      1.80-SINK    80.99    75.45   29.53    31.16   2,373        100.00   67.10   24.46    25.86   3,837
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                         SPECIFIC GRAVITY ANALYSIS OF FLOWSTREAM NUMBER 23 (CONTINUED)

                      ORIGIN - UNIT NUMBER  14   R        DESTINATION - UNIT NUMBER  15

                                 SPECIFIC             DIRECT, PERCENT                                 CUMULATIVE, PERCENT
 SIZE FRACTION AND WEIGHT        GRAVITY     WEIGHT    ASH  PYRITIC  TOTAL   BTU/LB       WEIGHT    ASH  PYRITIC  TOTAL   BTU/LB
                                                            SULFUR  SULFUR                               SULFUR  SULFUR

8M BY 28M                       FLOAT-1.30    0.21    1.95    0.18    0.68  15,355         0.21    1.95    0.18    0.68  15,355
PERCENT OF FLOW  15.1            1.30-1.35    0.25    4.44    0.41    0.94  14,907         0.46    3.30    0.31    0.82  15,112
                                 1.35-1.40    0.28    9.05    0.88    1.38  13,909         0.74    5.51    0.53    1.04  14,651
                                 1.40-1.50    1.99   15.57    1.48    2.03  12,682         2.73   12.84    1.22    1.76  13,215
                                 1.50-1.60    4.67   25.58    2.14    2.63  11,077         7.40   20.88    1.80    2.31  11,866
                                 1.60-1.70    6.11   33.14    3.52    4.09   9,723        13.51   26.42    2.58    3.11  10,897
                                 1.70-1.80    3.93   42.66    5.70    6.22   8,269        17.44   30.09    3.28    3.81  10,304
                                 1.80-SINK   82.56   76.51   27.24   28.84   2,250       100.00   68.41   23.06   24.47   3,655

28M BY 100M                     FLOAT-1.30    1.74    1.86    0.16    0.72  15,355         1.74    1.86    0.16    0.72  15,355
PERCENT OF FLOW   4.8            1.30-1.35    1.06    5.61    0.58    1.10  14,907         2.80    3.28    0.32    0.86  15,185
                                 1.35-1.40    1.16    8.52    0.97    1.45  13,909         3.96    4.81    0.51    1.03  14,813
                                 1.40-1.50    2.40   15.56    1.72    2.29  12,682         6.35    8.87    0.97    1.51  14,009
                                 1.50-1.60    3.70   24.97    2.42    2.90  11,077        10.06   14.79    1.50    2.02  12,929
                                 1.60-1.70    4.39   32.39    3.68    4.27   9,723        14.45   20.14    2.17    2.70  11,955
                                 1.70-1.80    3.10   41.32    5.77    6.35   8,269        17.55   23.88    2.80    3.35  11,304
                                 1.80-SINK   82.45   73.45   27.57   29.21   2,271       100.00   64.75   23.22   24.67   3,856

100M BY 325M                    FLOAT-1.30    1.11    1.43    0.12    0.66  15,355         1.11    1.43    0.12    0.66  15,355
PERCENT OF FLOW   2.1            1.30-1.35    1.57    3.21    0.33    0.88  14,907         2.68    2.47    0.24    0.79  15,092
                                 1.35-1.40    2.37    4.86    0.49    1.07  13,909         5.05    3.59    0.36    0.92  14,537
                                 1.40-1.50    3.27   12.56    1.31    1.84  12,682         8.32    7.12    0.73    1.29  13,807
                                 1.50-1.60    4.01   21.53    2.34    2.88  11,077        12.33   11.81    1.26    1.81  12,920
                                 1.60-1.70    3.81   29.89    3.77    4.24   9,723        16.14   16.07    1.85    2.38  12,165
                                 1.70-1.80    2.60   38.94    6.24    6.82   8,269        18.73   19.24    2.46    2.39  11,625
                                 1.80-SINK   81.27   69.53   28.83   30.28   2,145       100.00   60.11   23.89   25.17   3,921

COMPOSITE                       FLOAT-1.30    0.61    2.62    0.18    0.77  15,355         0.61    2.62    0.18    0.77  15,355
FLOWRATE          224.4          1.30-1.35    0.49    4.61    0.59    1.23  14,907         1.11    3.51    0.36    0.98  15,155
                                 1.35-1.40    0.28    8.29    0.87    1.42  13,909         1.39    4.48    0.47    1.07  14,900
                                 1.40-1.50    1.67   15.51    1.53    2.10  12,682         3.06   10.50    1.05    1.63  13,690
                                 1.50-1.60    2.50   25.58    2.08    2.55  11,077         5.56   17.28    1.51    2.05  12,515
                                 1.60-1.70    2.98   33.10    3.46    3.99   9,723         8.54   22.80    2.19    2.72  11,540
                                 1.70-1.80    2.09   42.44    5.43    5.92   8,269        10.63   26.66    2.83    3.35  10,898
                                 1.80-SINK   89.37   83.60   18.79   19.89   1,554       100.00   77.55   17.09   18.14   2,547
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                                                                                                   USER HANDBOOK EXAMPLE PAGE 50

                                        SUMMARY OF THE PRE-BREAKAGE PERFORMANCE OF UNIT NUMBER    15

                                                          CENTRIFUGE

SIZE, INCHES OR MESH                              18         12          6          2        1/2         8M        28M       100M       COMP
                                                  BY         BY         BY         BY         BY         BY         BY         BY
                                                  12          6          2        1/2         8M        28M       100M       325M

SCREEN ANALYSIS, PERCENT-
   FEED....................................     6.89      22.83      28.62       9.07      10.58      15.14       4.78       2.08     100.00
   BROKEN FEED.............................     2.53      11.82      24.84      19.25      14.75      15.41       7.74       3.66     100.00

ASH, PERCENT
   FEED....................................    97.73      94.55      74.98      65.67      67.10      68.41      64.75      60.11      77.55
   BROKEN FEED.............................    97.73      95.02      82.40      76.99      71.08      68.78      66.47      63.50      77.55

PYRITIC SULFUR, PERCENT
   FEED....................................     0.43       0.97      22.63      29.54      24.46      23.06      23.22      23.89      17.09
   BROKEN FEED.............................     0.43       0.89      14.60      19.52      22.83      23.13      23.21      23.59      17.09

TOTAL SULFUR, PERCENT
   FEED....................................     0.46       1.05      23.78      32.12      25.86      24.47      24.67      25.17      18.14
   BROKEN FEED.............................     0.46       0.97      15.36      20.84      24.27      24.55      24.65      24.93      18.14

BTU/LB, MOISTURE FREE
   FEED....................................      332        793      2,765      3,600      3,837      3,655      3,856      3,921      2,547
   BROKEN FEED.............................      332        724      2,007      2,527      3,281      3,601      3,745      3,806      2,547
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                                                                                                    USER HANDBOOK EXAMPLE PAGE 51

                                       SUMMARY OF THE PERFORMANCE CHARACTERISTICS OF UNIT NUMBER 15

                                                               CENTRIFUGE
                                                 UPPER FLOW STREAM = 99.0 PERCENT OF FEED

SIZE, INCHES OR MESH                          18        12         6         2       1/2        8M       28M      100M      COMP
                                              BY        BY        BY        BY        BY        BY        BY        BY
                                              12         6         2       1/2        8M       28M      100M      325M

SCREEN ANALYSIS, PERCENT-
   FEED..................................   6.89     22.83     28.62      9.07     10.58     15.14      4.78      2.08    100.00
   PRODUCT 1 (UPPER STREAM)..............   2.53     11.82     24.84     19.25     14.75     15.41      7.74      3.66    100.00
   PRODUCT 2 (LOWER STREAM)..............   2.53     11.82     24.84     19.25     14.75     15.41      7.74      3.66    100.00

ASH, PERCENT
   FEED..................................  97.73     94.55     74.98     65.67     67.10     68.41     64.75     60.11     77.55
   PRODUCT 1 (UPPER STREAM)..............  97.73     95.02     82.40     76.99     71.08     68.78     66.47     63.50     77.55
   PRODUCT 2 (LOWER STREAM)..............  97.73     95.02     82.40     76.99     71.08     68.78     66.47     63.50     77.55

PYRITIC SULFUR, PERCENT
   FEED..................................   0.43      0.97     22.63     29.54     24.46     23.06     23.22     23.89     17.09
   PRODUCT 1 (UPPER STREAM)..............   0.43      0.89     14.60     19.52     22.83     23.13     23.21     23.59     17.09
   PRODUCT 2 (LOWER STREAM)..............   0.43      0.89     14.60     19.52     22.83     23.13     23.21     23.59     17.09

TOTAL SULFUR, PERCENT
   FEED..................................   0.46      1.05     23.78     32.12     25.86     24.47     24.67     25.17     18.14
   PRODUCT 1 (UPPER STREAM)..............   0.46      0.97     15.36     20.84     24.27     24.55     24.65     24.93     18.14
   PRODUCT 2 (LOWER STREAM)..............   0.46      0.97     15.36     20.84     24.27     24.55     24.65     24.93     18.14

BTU/LB, MOISTURE FREE
   FEED..................................    332       793     2,765     3,600     3,837     3,655     3,856     3,921     2,547
   PRODUCT 1 (UPPER STREAM)..............    332       724     2,007     2,527     3,281     3,601     3,745     3,806     2,547
   PRODUCT 2 (LOWER STREAM)..............    332       724     2,007     2,527     3,281     3,601     3,745     3,806     2,547
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                            SPECIFIC GRAVITY ANALYSIS OF FLOWSTREAM NUMBER 24

                  ORIGIN - UNIT NUMBER  15   U       DESTINATION - UNIT NUMBER   8

                                                 DIRECT, PERCENT                                     CUMULATIVE, PERCENT
                                  SPECIFIC              ASH  PYRITIC  TOTAL   BTU/LB          WEIGHT   ASH  PYRITIC  TOTAL  BTU/LB
  SIZE FRACTION AND WEIGHT        GRAVITY    WEIGHT          SULFUR   SULFUR                                SULFUR  SULFUR

   18 BY 12                     FLOAT-1.30    0.85     2.80    0.21    0.79  15,355             0.85    2.80    0.21    0.79  15,355
   PERCENT OF FLOW   2.5         1.30-1.35    0.48     4.40    0.71    1.57  14,907             1.33    3.37    0.39    1.07  15,194
                                 1.35-1.40    0.09     7.80    0.98    1.59  13,909             1.42    3.66    0.43    1.10  15,112
                                 1.40-1.50    0.49    15.40    1.10    1.60  12,682             1.91    6.67    0.60    1.23  14,489
                                 1.50-1.60    0.09    25.00    1.44    1.84  11,077             2.00    7.50    0.64    1.26  14,334
                                 1.60-1.70    0.08    31.50    2.90    3.50   9,723             2.08    8.45    0.73    1.35  14,152
                                 1.70-1.80    0.03    41.00    5.46    6.13   8,269             2.11    8.98    0.80    1.43  14,055
                                 1.80-SINK   97.89    99.65    0.42    0.44      35           100.00   97.73    0.43    0.46     332

   12 BY 6                      FLOAT-1.30    1.69     2.86    0.19    0.80  15,355             1.68    2.86    0.19    0.80  15,355
   PERCENT OF FLOW  11.8         1.30-1.35    1.24     4.61    0.65    1.32  14,907             2.92    3.61    0.39    1.02  15,164
                                 1.35-1.40    0.40     9.12    1.04    1.64  13,909             3.32    4.27    0.46    1.09  15,014
                                 1.40-1.50    0.70    16.01    1.30    1.82  12,682             4.01    6.31    0.61    1.22  14,609
                                 1.50-1.60    0.32    26.34    1.86    2.33  11,077             4.34    7.80    0.70    1.30  14,346
                                 1.60-1.70    0.19    33.93    3.12    3.69   9,723             4.53    8.91    0.80    1.41  14,150
                                 1.70-1.80    0.10    44.47    5.91    6.45   8,269             4.63    9.68    0.91    1.51  14,022
                                 1.80-SINK   95.37    99.16    0.89    0.94      79           100.00   95.02    0.89    0.97     724

   6 BY 2                       FLOAT-1.30    0.61     2.86    0.19    0.80  15,355             0.61    2.86    0.19    0.80  15,355
   PERCENT OF FLOW  24.8         1.30-1.35    0.45     4.61    0.65    1.33  14,907             1.06    3.60    0.39    1.02  15,165
                                 1.35-1.40    0.14     9.11    1.04    1.64  13,909             1.20    4.26    0.46    1.09  15,016
                                 1.40-1.50    1.90    15.60    1.68    2.26  12,682             3.10   11.21    1.21    1.81  13,585
                                 1.50-1.60    1.38    25.82    2.21    2.73  11,077             4.47   15.70    1.52    2.09  12,814
                                 1.60-1.70    1.70    32.80    3.61    4.22   9,723             6.17   20.40    2.09    2.68  11,964
                                 1.70-1.80    0.95    43.05    5.77    6.40   8,269             7.13   23.45    2.59    3.18  11,467
                                 1.80-SINK   92.87    86.93   15.53   16.30   1,281           100.00   82.40   14.60   15.36   2,007

   2 BY 1/2                     FLOAT-1.30    0.39     2.86    0.19    0.80  15,355             0.39    2.86    0.19    0.80  15,355
   PERCENT OF FLOW  19.3         1.30-1.35    0.32     4.61    0.64    1.31  14,907             0.71    3.65    0.39    1.02  15,154
                                 1.35-1.40    0.12     9.17    1.03    1.61  13,909             0.83    4.42    0.48    1.11  14,979
                                 1.40-1.50    1.57    15.63    1.67    2.25  12,682             2.40   11.77    1.26    1.86  13,473
                                 1.50-1.60    1.95    25.91    2.14    2.63  11,077             4.35   18.11    1.66    2.20  12,398
                                 1.60-1.70    2.25    33.24    3.55    4.12   9,723             6.61   23.28    2.30    2.86  11,485
                                 1.70-1.80    1.68    43.02    5.72    6.29   8,269             8.29   27.27    2.99    3.55  10,834
                                 1.80-SINK   91.71    81.48   21.02   22.40   1,776           100.00   76.99   19.52   20.84   2,527

   1/2 BY 8M                    FLOAT-1.30    0.16     2.86    0.19    0.79  15,355             0.16    2.86    0.19    0.79  15,355
   PERCENT OF FLOW  14.7         1.30-1.35    0.22     4.67    0.47    1.11  14,907             0.37    3.91    0.36    0.98  15,095
                                 1.35-1.40    0.15     9.45    0.74    1.25  13,909             0.52    5.51    0.47    1.06  14,751
                                 1.40-1.50    1.61    15.70    1.31    1.87  12,682             2.13   13.20    1.[illegible]0    1.67  13,189
                                 1.50-1.60    3.86    25.85    1.84    2.28  11,077             5.99   21.35    1.58    2.06  11,829
                                 1.60-1.70    4.43    33.56    3.22    3.65   9,723            10.42   26.54    2.28    2.74  10,934
                                 1.70-1.80    3.55    42.29    4.84    5.21   8,269            13.98   30.55    2.93    3.36  10,256
                                 1.80-SINK   86.02    77.66   26.06   27.67   2,147           100.00   71.08   22.83   24.27   3,281
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                              SPECIFIC GRAVITY ANALYSIS OF FLOWSTREAM NUMBER 24 (CONTINUED)

                           ORIGIN - UNIT NUMBER  15   U        DESTINATION - UNIT NUMBER   0

                                                                                                    CUMULATIVE. PERCENT
                                       SPECIFIC                 DIRECT. PERCENT                                   WEIGHT     ASH  PYRITIC   TOTAL   BTU/LB
     SIZE FRACTION AND WEIGHT          GRAVITY      WEIGHT     ASH  PYRITIC   TOTAL   BTU/LB                              SULFUR  SULFUR
                                                                    SULFUR   SULFUR

                                      FLOAT-1.30     0.19     2.08    0.18     0.70  15,355           0.19     2.08    0.18     0.70  15,355
 8M BY 28M                             1.30-1.35     0.24     4.49    0.42     0.96  14,907           0.42     3.42    0.31     0.85  15,105
 PERCENT OF FLOW  15.4                 1.35-1.40     0.26     9.11    0.86     1.36  13,909           0.68     5.56    0.52     1.04  14,656
                                       1.40-1.50     1.91    15.60    1.43     1.99  12,682           2.58    12.96    1.19     1.74  13,201
                                       1.50-1.60     4.57    25.63    2.07     2.55  11,077           7.15    21.05    1.75     2.25  11,844
                                       1.60-1.70     5.82    33.23    3.46     4.00   9,723          12.97    26.51    2.52     3.04  10,893
                                       1.70-1.80     3.93    42.56    5.48     5.97   8,269          16.90    30.24    3.21     3.72  10,283
                                       1.80-SINK    83.10    76.62   27.18    28.79   2,242         100.00    68.78   23.13    24.55   3,601

                                      FLOAT-1.30     1.08     1.88    0.16     0.72  15,355           1.08     1.88    0.16     0.72  15,355
 28M BY 100M                           1.30-1.35     0.71     5.46    0.56     1.08  14,907           1.79     3.30    0.32     0.86  15,177
 PERCENT OF FLOW   7.7                 1.35-1.40     0.77     8.61    0.95     1.43  13,909           2.56     4.90    0.51     1.03  14,795
                                       1.40-1.50     2.18    15.58    1.61     2.17  12,682           4.74     9.81    1.01     1.56  13,824
                                       1.50-1.60     4.07    25.29    2.24     2.72  11,077           8.81    16.96    1.58     2.09  12,555
                                       1.60-1.70     4.97    32.82    3.56     4.12   9,723          13.78    22.68    2.30     2.82  11,533
                                       1.70-1.80     3.46    41.90    5.60     6.12   8,269          17.24    26.54    2.96     3.49  10,878
                                       1.80-SINK    82.76    74.79   27.43    29.05   2,259         100.00    66.47   23.21    24.65   3,745

                                      FLOAT-1.30     0.84     1.56    0.13     0.68  15,355           0.84     1.56    0.13     0.68  15,355
 100M BY 325M                          1.30-1.35     1.07     3.51    0.36     0.91  14,907           1.91     2.65    0.26     0.81  15,105
 PERCENT OF FLOW   3.7                 1.35-1.40     1.53     5.35    0.54     1.11  13,909           3.44     3.85    0.38     0.94  14,572
                                       1.40-1.50     2.72    13.52    1.37     1.91  12,682           6.16     8.12    0.82     1.37  13,737
                                       1.50-1.60     4.18    23.36    2.24     2.75  11,077          10.34    14.29    1.39     1.93  12,661
                                       1.60-1.70     4.55    31.58    3.62     4.12   9,723          14.89    19.57    2.07     2.60  11,763
                                       1.70-1.80     3.11    40.73    5.85     6.36   8,269          18.00    23.23    2.73     3.25  11,159
                                       1.80-SINK    82.00    72.35   28.17    29.69   2,192         100.00    63.50   23.59    24.93   3,806

                                      FLOAT-1.30     0.61     2.62    0.18     0.77  15,355           0.61     2.62    0.18     0.77  15.355
 COMPOSITE                             1.30-1.35     0.49     4.61    0.59     1.23  14,907           1.11     3.51    0.36     0.98  15,155
 FLOWRATE           222.2              1.35-1.40     0.28     8.29    0.87     1.42  13,909           1.39     4.48    0.47     1.07  14,900
                                       1.40-1.50     1.67    15.51    1.53     2.10  12,682           3.06    10.50    1.05     1.63  13,690
                                       1.50-1.60     2.50    25.58    2.08     2.55  11,077           5.56    17.28    1.51     2.05  12,515
                                       1.60-1.70     2.98    33.10    3.46     3.99   9,723           8.54    22.80    2.19     2.72  11,540
                                       1.70-1.80     2.09    42.44    5.43     5.92   8,269          10.63    26.66    2.83     3.35  10,898
                                       1.80-SINK    89.37    83.60   18.79    19.89   1,554         100.00    77.55   17.09    18.14   2,547
                              SPECIFIC GRAVITY ANALYSIS OF FLOWSTREAM NUMBER 25

                         ORIGIN - UNIT NUMBER  15   L       DESTINATION - UNIT NUMBER   2

                                                                                            CUMULATIVE, PERCENT
                                       SPECIFIC            DIRECT, PERCENT
     SIZE FRACTION AND WEIGHT          GRAVITY     WEIGHT    ASH  PYRITIC   TOTAL   BTU/LB     WEIGHT    ASH  PYRITIC   TOTAL  BTU/LB
                                                                  SULFUR   SULFUR                             SULFUR   SULFUR

18 BY 12                              FLOAT-1.30     0.85    2.80    0.21    0.79   15,355       0.85    2.80    0.21    0.79  15,355
PERCENT OF FLOW   2.5                  1.30-1.35     0.48    4.40    0.71    1.57   14,907       1.33    3.37    0.39    1.07  15,194
                                       1.35-1.40     0.09    7.80    0.98    1.59   13,909       1.42    3.66    0.43    1.10  15,112
                                       1.40-1.50     0.49   15.40    1.10    1.60   12,682       1.91    6.67    0.60    1.23  14,489
                                       1.50-1.60     0.09   25.00    1.44    1.84   11,077       2.00    7.50    0.64    1.26  14,334
                                       1.60-1.70     0.08   31.50    2.90    3.50    9,723       2.08    8.45    0.73    1.35  14,152
                                       1.70-1.80     0.03   41.00    5.46    6.13    8,269       2.11    8.98    0.80    1.43  14,055
                                       1.80-SINK    97.89   99.65    0.42    0.44       35     100.00   97.73    0.43    0.46     332

12 BY 6                               FLOAT-1.30     1.68    2.86    0.19    0.80   15,355       1.68    2.86    0.19    0.80  15,355
PERCENT OF FLOW  11.8                  1.30-1.35     1.24    4.61    0.65    1.32   14,907       2.92    3.61    0.39    1.02  15,164
                                       1.35-1.40     0.40    9.12    1.04    1.64   13,909       3.32    4.27    0.46    1.09  15,014
                                       1.40-1.50     0.70   16.01    1.30    1.82   12,682       4.01    6.31    0.61    1.22  14,609
                                       1.50-1.60     0.32   26.34    1.86    2.33   11,077       4.34    7.80    0.70    1.30  14,346
                                       1.60-1.70     0.19   33.93    3.12    3.69    9,723       4.53    8.91    0.80    1.41  14,150
                                       1.70-1.80     0.10   44.47    5.91    6.45    8,269       4.63    9.68    0.91    1.51  14,022
                                       1.80-SINK    95.37   99.16    0.89    0.94       79     100.00   95.02    0.89    0.97     724

6 BY 2                                FLOAT-1.30     0.61    2.86    0.19    0.80   15,355       0.61    2.86    0.19    0.80  15,355
PERCENT OF FLOW  24.8                  1.30-1.35     0.45    4.61    0.65    1.33   14,907       1.06    3.60    0.39    1.02  15,165
                                       1.35-1.40     0.14    9.11    1.04    1.64   13,909       1.20    4.26    0.46    1.09  15,016
                                       1.40-1.50     1.90   15.60    1.68    2.26   12,682       3.10   11.21    1.21    1.81  13,585
                                       1.50-1.60     1.38   25.82    2.21    2.73   11,077       4.47   15.70    1.52    2.09  12,814
                                       1.60-1.70     1.70   32.80    3.61    4.22    9,723       6.17   20.40    2.09    2.68  11,964
                                       1.70-1.80     0.96   43.05    5.77    6.40    8,269       7.13   23.45    2.59    3.18  11,467
                                       1.80-SINK    92.87   86.93   15.53   16.30    1,281     100.00   82.40   14.60   15.36   2,007

2 BY 1/2                              FLOAT-1.30     0.39    2.86    0.19    0.80   15,355       0.39    2.86    0.19    0.80  15,355
PERCENT OF FLOW  19.3                  1.30-1.35     0.32    4.61    0.64    1.31   14,907       0.71    3.65    0.39    1.02  15,154
                                       1.35-1.40     0.12    9.17    1.03    1.61   13,909       0.83    4.42    0.48    1.11  14,979
                                       1.40-1.50     1.57   15.63    1.67    2.25   12,682       2.40   11.77    1.26    1.86  13,473
                                       1.50-1.60     1.95   25.91    2.14    2.63   11,077       4.35   18.11    1.66    2.20  12,398
                                       1.60-1.70     2.26   33.24    3.55    4.12    9,723       6.61   23.28    2.30    2.86  11,495
                                       1.70-1.80     1.68   43.02    5.72    6.29    8,269       8.29   27.27    2.99    3.55  10,834
                                       1.80-SINK    91.71   81.48   21.02   22.40    1,776     100.00   76.99   19.52   20.84   2,527

1/2 BY 8M                             FLOAT-1.30     0.16    2.86    0.19    0.79   15,355       0.16    2.86    0.19    0.79  15,355
PERCENT OF FLOW  14.7                  1.30-1.35     0.22    4.67    0.47    1.11   14,907       0.37    3.91    0.36    0.98  15,095
                                       1.35-1.40     0.15    9.45    0.74    1.25   13,909       0.52    5.51    0.47    1.06  14,751
                                       1.40-1.50     1.61   15.70    1.31    1.87   12,682       2.13   13.20    1.10    1.67  13,189
                                       1.50-1.60     3.86   25.85    1.84    2.28   11,077       5.99   21.35    1.58    2.06  11,829
                                       1.60-1.70     4.43   33.56    3.22    3.65    9,723      10.42   26.54    2.28    2.74  10,934
                                       1.70-1.80     3.56   42.29    4.84    5.21    8,269      13.98   30.55    2.93    3.36  10,256
                                       1.80-SINK    86.02   77.66   26.06   27.67    2,147     100.00   71.08   22.83   24.27   3,281
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                                   SPECIFIC GRAVITY ANALYSIS OF FLOWSTREAM NUMBER 25 (CONTINUED)

                              ORIGIN - UNIT NUMBER  15   L       DESTINATION - UNIT NUMBER   2

                                       SPECIFIC                DIRECT, PERCENT                                       CUMULATIVE, PERCENT
   SIZE FRACTION AND WEIGHT            GRAVITY      WEIGHT    ASH  PYRITIC  TOTAL   BTU/LB          WEIGHT    ASH  PYRITIC  TOTAL   BTU/LB
                                                                   SULFUR   SULFUR                                 SULFUR   SULFUR

8M BY 28M                            FLOAT-1.30     0.19     2.08    0.18    0.70  15,355           0.19     2.08    0.18    0.70  15,355
PERCENT OF FLOW  15.4                 1.30-1.35     0.24     4.49    0.42    0.96  14,907           0.42     3.42    0.31    0.85  15,105
                                      1.35-1.40     0.26     9.11    0.86    1.36  13,909           0.68     5.56    0.52    1.04  14,656
                                      1.40-1.50     1.91    15.60    1.43    1.99  12,682           2.58    12.96    1.19    1.74  13,201
                                      1.50-1.60     4.57    25.63    2.07    2.55  11.077           7.15    21.05    1.75    2.25  11,844
                                      1.60-1.70     5.82    33.23    3.46    4.00   9,723          12.97    26.51    2.52    3.04  10,893
                                      1.70-1.80     3.93    42.56    5.48    5.97   8,269          16.90    30.24    3.21    3.72  10,283
                                      1.80-SINK    83.10    76.62   27.18   28.79   2,242         100.00    68.78   23.13   24.55   3.601

28M BY 100M                          FLOAT-1.30     1.08     1.88    0.16    0.72  15,355           1.08     1.88    0.16    0.72  15,355
PERCENT OF FLOW   7.7                 1.30-1.35     0.71     5.46    0.56    1.08  14,907           1.79     3.30    0.32    0.86  15,177
                                      1.35-1.40     0.77     8.61    0.95    1.43  13,909           2.56     4.90    0.51    1.03  14,795
                                      1.40-1.50     2.18    15.58    1.61    2.17  12,682           4.74     9.81    1.01    1.56  13,824
                                      1.50-1.60     4.07    25.29    2.24    2.72  11,077           8.81    16.96    1.58    2.09  12,555
                                      1.60-1.70     4.97    32.82    3.56    4.12   9,723          13.78    22.68    2.30    2.82  11,533
                                      1.70-1.80     3.46    41.90    5.60    6.12   8,269          17.24    26.54    2.96    3.49  10,878
                                      1.80-SINK    82.76    74.79   27.43   29.05   2,259         100.00    66.47   23.21   24.65   3,745

100M BY 325M                         FLOAT-1.30     0.84     1.56    0.13    0.68  15,355           0.84     1.56    0.13    0.68  15,355
PERCENT OF FLOW   3.7                 1.30-1.35     1.07     3.51    0.36    0.91  14,907           1.91     2.65    0.26    0.81  15,105
                                      1.35-1.40     1.53     5.35    0.54    1.11  13,909           3.44     3.85    0.38    0.94  14,572
                                      1.40-1.50     2.72    13.52    1.37    1.91  12,682           6.16     8.12    0.82    1.37  13,737
                                      1.50-1.60     4.18    23.36    2.24    2.75  11,077          10.34    14.29    1.39    1.93  12,661
                                      1.60-1.70     4.55    31.58    3.62    4.12   9,723          14.89    19.57    2.07    2.60  11,763
                                      1.70-1.80     3.11    40.73    5.85    6.38   8,269          18.00    23.23    2.73    3.25  11,159
                                      1.80-SINK    82.00    72.35   28.17   29.69   2,192         100.00    63.50   23.59   24.93   3.806

COMPCSITE                            FLOAT-1.30     0.61     2.62    0.18    0.77  15,355           0.61     2.62    0.18    0.77  15,355
FLOWRATE             2.2              1.30-1.35     0.49     4.61    0.59    1.23  14,907           1.11     3.51    0.36    0.98  15,155
                                      1.35-1.40     0.28     8.29    0.87    1.42  13,909           1.39     4.48    0.47    1.07  14,900
                                      1.40-1.50     1.67    15.51    1.53    2.10  12,682           3.06    10.50    1.05    1.63  13,690
                                      1.50-1.60     2.50    25.58    2.08    2.55  11,077           5.56    17.28    1.51    2.05  12,515
                                      1.60-1.70     2.98    33.10    3.46    3.99   9,723           8.54    22.80    2.19    2.72  11,540
                                      1.70-1.80     2.09    42.44    5.43    5.92   8,269          10.63    26.66    2.83    3.35  10,898
                                      1.80-SINK    89.37    83.60   18.79   19.89   1,554         100.00    77.55   17.09   18.14   2,547
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                    SUMMARY OF THE PERFORMANCE CHARACTERISTICS OF UNIT NUMBER 16

                                               STREAM BLENDER

SIZE, INCHES OR MESH                             1/2        8M       28M      100M      COMP
                                                  BY        BY        BY        BY
                                                  8M       28M      100M      325M

SCREEN ANALYSIS, PERCENT-
   PRODUCT..................................  46.18     24.63     15.17     14.02    100.00
   FEED 1...................................  51.31     27.37     12.74      8.58    100.00
   FEED 2......... .........................   0.00      0.00     37.05     62.95    100.00

ASH, PERCENT
   PRODUCT..................................   6.41      6.97      7.58      7.63      6.90
   FEED 1...................................   6.41      6.97      8.21     10.47      7.14
   FEED 2...................................   0.00      0.00      5.62      4.15      4.70

PYRITIC SULFUR, PERCENT
   PRODUCT..................................   0.42      0.86      1.28      1.88      0.86
   FEED 1...................................   0.42      0.86      1.44      2.95      0.89
   FEED 2...................................   0.00      0.00      0.78      0.56      0.64

TOTAL SULFUR, PERCENT
   PRODUCT..................................   0.98      1.39      1.85      2.47      1.42
   FEED 1...................................   0.98      1.39      2.02      3.58      1.45
   FEED 2...................................   0.00      0.00      1.33      1.12      1.20

BTU/LB, MOISTURE FREE
   PRODUCT.................................. 14,585    14,421    14,317    13,971    14,418
   FEED 1................................... 14,585    14,421    14,200    13,424    14,391
   FEED 2...................................      0         0    14,678    14,642    14,655
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                                    SPECIFIC GRAVITY ANALYSIS OF FLOWSTREAM NUMBER 26

                         ORIGIN - UNIT NUMBER  16   C        DESTINATION - UNIT NUMBER  17

                                      SPECIFIC               DIRECT, PERCENT                                        CUMULATIVE, PERCENT
     SIZE FRACTION AND WEIGHT         GRAVITY      WEIGHT     ASH  PYRITIC   TOTAL   BTU/LB         WEIGHT     ASH  PYRITIC   TOTAL   BTU/LB
                                                                   SULFUR   SULFUR                                  SULFUR   SULFUR

  1/2 BY 8M                          FLOAT-1.30    44.20     2.47     0.10     0.67  15,355          44.20    2.47     0.10     0.67  15,355
  PERCENT OF FLOW  46.2                1.30-1.35   31.07     4.75     0.23     0.81  14,907          75.26    3.41     0.15     0.73  15,170
                                       1.35-1.40    9.96     9.58     0.59     1.07  13,909          85.22    4.13     0.20     0.77  15,023
                                       1.40-1.50   10.85    15.75     1.02     1.56  12,682          96.07    5.45     0.29     0.86  14,758
                                       1.50-1.60    3.08    25.82     1.73     2.16  11,077          99.15    6.08     0.34     0.90  14,644
                                       1.60-1.70    0.54    33.65     3.11     3.48   9,723          99.70    6.23     0.35     0.91  14,617
                                       1.70-1.80    0.09    42.03     4.53     4.84   8,269          99.78    6.26     0.36     0.92  14,612
                                       1.80-SINK    0.22    75.45    29.52    31.15   2,373         100.00    6.41     0.42     0.98  14,585

  8M BY 28M                          FLOAT-1.30    51.26     1.95     0.18     0.68  15,355          51.26    1.95     0.18     0.68  15,355
  PERCENT OF FLOW  24.6                1.30-1.35   24.06     4.44     0.41     0.94  14,907          75.32    2.75     0.25     0.77  15,212
                                       1.35-1.40    7.20     9.05     0.88     1.38  13,909          82.52    3.30     0.31     0.82  15,098
                                       1.40-1.50    9.47    15.57     1.48     2.03  12,682          91.99    4.56     0.43     0.94  14,850
                                       1.50-1.60    4.82    25.58     2.14     2.63  11,077          96.81    5.61     0.52     1.03  14,662
                                       1.60-1.70    1.78    33.14     3.52     4.09   9,723          98.59    6.10     0.57     1.08  14,573
                                       1.70-1.80    0.39    42.66     5.70     6.22   8,269          98.97    6.25     0.59     1.10  14,548
                                       1.80-SINK    1.03    76.51    27.24    28.84   2,250         100.00    6.97     0.86     1.39  14,421

  28M BY 100M                        FLOAT-1.30    59.47     1.86     0.16     0.72  15,355          59.47    1.86     0.16     0.72  15,355
  PERCENT OF FLOW  15.2                1.30-1.35   16.41     5.61     0.59     1.10  14,907          75.88    2.67     0.25     0.80  15,258
                                       1.35-1.40    8.28     8.52     0.97     1.45  13,909          84.16    3.25     0.32     0.87  15,125
                                       1.40-1.50    6.39    15.56     1.72     2.29  12,682          90.54    4.11     0.42     0.97  14,953
                                       1.50-1.60    3.89    24.97     2.42     2.90  11,077          94.43    4.97     0.50     1.05  14,793
                                       1.60-1.70    2.27    32.39     3.68     4.27   9,723          96.70    5.62     0.58     1.12  14,675
                                       1.70-1.80    0.86    41.32     5.77     6.35   8,269          97.56    5.93     0.62     1.17  14,618
                                       1.80-SINK    2.44    73.45    27.57    29.21   2,271         100.00    7.58     1.28     1.85  14,317

  100M BY 325M                       FLOAT-1.30    45.11     1.43     0.12     0.66  15,355          45.11    1.43     0.12     0.66  15,355
  PERCENT OF FLOW  14.0                1.30-1.35   24.40     3.21     0.33     0.88  14,907          69.51    2.05     0.19     0.74  15,198
                                       1.35-1.40   14.56     4.86     0.49     1.07  13,909          84.07    2.54     0.24     0.80  14,975
                                       1.40-1.50    6.12    12.56     1.31     1.84  12,682          90.19    3.22     0.32     0.87  14,819
                                       1.50-1.60    2.78    21.53     2.34     2.88  11,077          92.97    3.77     0.38     0.93  14,707
                                       1.60-1.70    1.44    29.89     3.77     4.24   9,723          94.41    4.17     0.43     0.98  14,631
                                       1.70-1.80    0.61    38.94     6.24     6.82   8,269          95.02    4.39     0.47     1.02  14,590
                                       1.80-SINK    4.98    69.53    28.03    30.28   2,145         100.00    7.63     1.88     2.47  13,971

  COMPOSITE                          FLOAT-1.30    48.38     2.08     0.13     0.68  15,355          48.38    2.08     0.13     0.68  15,355
  FLOWRATE            114.4            1.30-1.35   26.18     4.56     0.32     0.88  14,907          74.56    2.95     0.20     0.75  15,198
                                       1.35-1.40    9.67     8.35     0.67     1.18  13,909          84.23    3.57     0.25     0.80  15,050
                                       1.40-1.50    9.17    15.39     1.24     1.78  12,682          93.40    4.73     0.35     0.90  14,817
                                       1.50-1.60    3.59    25.13     2.05     2.51  11,077          96.99    5.49     0.41     0.96  14,679
                                       1.60-1.70    1.24    32.51     3.53     4.04   9,723          98.23    5.83     0.45     1.00  14,617
                                       1.70-1.80    0.35    41.18     5.73     6.26   8,269          98.58    5.95     0.47     1.01  14,594
                                       1.80-SINK    1.42    72.21    28.27    29.81   2,213         100.00    6.90     0.86     1.42  14,418
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                                                                                              USER HANDBOOK EXAMPLE PAGE 58

                               SUMMARY OF THE PERFORMANCE CHARACTERISTICS OF UNIT NUMBER 17

                                                   STREAM BLENDER

SIZE, INCHES OR MESH                           6         2       1/2        8M       28M      100M      COMP
                                              BY        BY        BY        BY        BY        BY
                                               2       1/2        8M       28M      100M      325M

SCREEN ANALYSIS, PERCENT-
   PRODUCT..............................   34.98     22.89     20.14     10.07      6.19      5.72    100.00
   FEED 1...............................   59.06     38.65      2.21      0.04      0.01      0.01    100.00
   FEED 2...............................    0.00      0.00     46.18     24.63     15.17     14.02    100.00

ASH, PERCENT
   PRODUCT..............................    6.65      8.01      6.61      6.97      7.58      7.63      7.10
   FEED 1...............................    6.65      8.01      9.53      9.35      8.45      7.49      7.24
   FEED 2...............................    0.00      0.00      6.41      6.97      7.58      7.63      6.90

PYRITIC SULFUR, PERCENT
   PRODUCT..............................    0.71      0.96      0.49      0.87      1.28      1.88      0.84
   FEED 1...............................    0.71      0.96      1.50      2.05      2.17      2.23      0.82
   FEED 2...............................    0.00      0.00      0.42      0.86      1.28      1.88      0.86

TOTAL SULFUR, PERCENT
   PRODUCT..............................    1.34      1.56      1.06      1.39      1.85      2.47      1.44
   FEED 1...............................    1.34      1.56      2.09      2.60      2.76      2.82      1.44
   FEED 2...............................    0.00      0.00      0.98      1.39      1.85      2.47      1.42

BTU/LB, MOISTURE FREE
   PRODUCT..............................  14,522    14,290    14,549    14,420    14,316    13,970    14,420
   FEED 1...............................  14,522    14,290    14,033    14,004    14,055    13,883    14,421
   FEED 2...............................       0         0    14,585    14,421    14,317    13,971    14,418
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                         SPECIFIC GRAVITY ANALYSIS OF FLOWSTREAM NUMBER 27

                    ORIGIN - UNIT NUMBER  17   C        DESTINATION - UNIT NUMBER  18

                                  SPECIFIC              DIRECT, PERCENT                                  CUMULATIVE, PERCENT
     SIZE FRACTION AND WEIGHT     GRAVITY     WEIGHT    ASH  PYRITIC   TOTAL   BTU/LB      WEIGHT    ASH  PYRITIC   TOTAL   BTU/LB
                                                             SULFUR   SULFUR                              SULFUR   SULFUR

 6 BY 2                          FLOAT-1.30   44.04    2.83    0.15    0.80  15,355       44.04    2.83    0.15    0.80  15.355
 PERCENT OF FLOW  35.0            1.30-1.35   27.84    4.50    0.64    1.31  14,907       71.87    3.48    0.34    1.00  15.181
                                  1.35-1.40    6.97    8.62    1.13    1.73  13,909       78.84    3.93    0.41    1.06  15.069
                                  1.40-1.50   18.75   15.54    1.74    2.33  12,682       97.59    6.16    0.66    1.30  14.610
                                  1.50-1.60    2.21   25.78    2.24    2.77  11,077       99.80    6.60    0.70    1.34  14.532
                                  1.60-1.70    0.17   32.75    3.63    4.24   9,723       99.97    6.64    0.71    1.34  14.524
                                  1.70-1.80    0.03   42.99    5.76    6.40   8,269      100.00    6.65    0.71    1.34  14.522
                                  1.80-SINK    0.00    0.00    0.00    0.00       0      100.00    6.65    0.71    1.34  14.522

 2 BY 1/2                        FLOAT-1.30   38.07    2.62    0.15    0.78  15,355       38.07    2.62    0.15    0.78  15.355
 PERCENT OF FLOW  22.9            1.30-1.35   30.44    4.64    0.55    1.12  14,907       68.51    3.52    0.33    0.93  15.156
                                  1.35-1.40    9.80    9.35    1.00    1.51  13,909       78.32    4.25    0.41    1.01  15,000
                                  1.40-1.50   14.49   15.92    1.52    2.08  12,682       92.80    6.07    0.59    1.17  14,638
                                  1.50-1.60    4.68   26.02    2.06    2.52  11,077       97.48    7.03    0.66    1.24  14.467
                                  1.60-1.70    1.42   33.81    3.46    3.98   9,723       98.90    7.41    0.70    1.28  14,399
                                  1.70-1.80    0.34   43.01    5.69    6.21   8,269       99.24    7.53    0.72    1.29  14,378
                                  1.80-SINK    0.76   69.61   32.65   35.48   2,841      100.00    8.01    0.96    1.56  14,290

 1/2 BY 8M                       FLOAT-1.30   44.03    2.47    0.10    0.67  15,355       44.03    2.47    0.10    0.67  15,355
 PERCENT OF FLOW  20.1            1.30-1.35   30.94    4.75    0.23    0.81  14,907       74.97    3.41    0.15    0.73  15,170
                                  1.35-1.40    9.91    9.58    0.59    1.07  13,909       84.88    4.13    0.20    0.77  15.023
                                  1.40-1.50   10.79   15.75    1.02    1.55  12,682       95.67    5.44    0.29    0.86  14.759
                                  1.50-1.60    3.13   25.82    1.73    2.15  11,077       98.80    6.09    0.34    0.90  14.642
                                  1.60-1.70    0.62   33.66    3.10    3.46   9,723       99.42    6.26    0.36    0.92  14.612
                                  1.70-1.80    0.14   41.98    4.47    4.76   8,269       99.56    6.31    0.36    0.92  14,603
                                  1.80-SINK    0.44   75.33   29.80   31.43   2,386      100.00    6.61    0.49    1.06  14,549

 8M BY 28M                       FLOAT-1.30   51.26    1.95    0.18    0.68  15,355       51.26    1.95    0.18    0.68  15,355
 PERCENT OF FLOW  10.1            1.30-1.35   24.06    4.44    0.41    0.94  14,907       75.32    2.75    0.25    0.77  15.212
                                  1.35-1.40    7.20    9.05    0.88    1.38  13,909       82.52    3.30    0.31    0.82  15.098
                                  1.40-1.50    9.46   15.57    1.48    2.03  12,682       91.98    4.56    0.43    0.94  14,850
                                  1.50-1.60    4.81   25.57    2.14    2.63  11,077       96.79    5.60    0.51    1.03  14.662
                                  1.60-1.70    1.78   33.14    3.52    4.09   9,723       98.57    6.10    0.57    1.08  14,573
                                  1.70-1.80    0.39   42.65    5.70    6.22   8,269       98.96    6.24    0.59    1.10  14,548
                                  1.80-SINK    1.04   76.50   27.26   28.86   2,251      100.00    6.97    0.87    1.39  14,420

 28M BY 100M                     FLOAT-1.30   59.47    1.86    0.16    0.72  15,355       59.47    1.86    0.16    0.72  15,355
 PERCENT OF FLOW   6.2            1.30-1.35   16.41    5.61    0.58    1.10  14,907       75.88    2.67    0.25    0.80  15.258
                                  1.35-1.40    8.28    8.52    0.97    1.45  13,909       84.16    3.25    0.32    0.87  15.125
                                  1.40-1.50    6.38   15.56    1.72    2.29  12,682       90.54    4.11    0.42    0.97  14.953
                                  1.50-1.60    3.89   24.97    2.42    2.91  11,077       94.43    4.97    0.50    1.05  14.794
                                  1.60-1.70    2.27   32.39    3.68    4.27   9,723       96.70    5.61    0.58    1.12  14,675
                                  1.70-1.80    0.86   41.31    5.77    6.35   8,269       97.55    5.93    0.62    1.17  14,618
                                  1.80-SINK    2.45   73.42   27.56   29.21   2,271      100.00    7.58    1.28    1.85  14,316
                         SPECIFIC GRAVITY ANALYSIS OF FLOWSTREAM NUMBER 27 (CONTINUED)

                      ORIGIN - UNIT NUMBER  17   C        DESTINATION - UNIT NUMBER  18

                              SPECIFIC                DIRECT, PERCENT                                 CUMULATIVE, PERCENT
   SIZE FRACTION AND WEIGHT   GRAVITY     WEIGHT    ASH  PYRITIC   TOTAL   BTU/LB       WEIGHT     ASH  PYRITIC   TOTAL   BTU/LB
                                                         SULFUR  SULFUR                                  SULFUR  SULFUR

 100M BY 325M                FLOAT-1.30    45.11    1.43    0.12    0.66  15,355        45.11    1.43    0.12    0.66  15,355
 PERCENT OF FLOW   5.7        1.30-1.35    24.40    3.21    0.33    0.88  14,907        69.51    2.05    0.19    0.74  15,198
                              1.35-1.40    14.56    4.86    0.49    1.07  13,909        84.07    2.54    0.24    0.80  14,975
                              1.40-1.50     6.12   12.56    1.31    1.84  12,682        90.19    3.22    0.32    0.87  14,819
                              1.50-1.60     2.78   21.53    2.34    2.88  11,077        92.97    3.77    0.38    0.93  14,707
                              1.60-1.70     1.44   29.89    3.77    4.24   9,723        94.41    4.17    0.43    0.98  14,631
                              1.70-1.80     0.61   38.94    6.25    6.82   8,269        95.02    4.39    0.47    1.02  14,590
                              1.80-SINK     4.98   69.52   28.83   30.28   2,145       100.00    7.63    1.88    2.47  13,970

 COMPOSITE                   FLOAT-1.30    44.41    2.45    0.14    0.74  15,355        44.41    2.45    0.14    0.74  15,355
 FLOWRATE          280.7      1.30-1.35    27.77    4.57    0.49    1.09  14,907        72.19    3.26    0.28    0.88  15,183
                              1.35-1.40     8.75    8.70    0.88    1.42  13,909        80.94    3.85    0.34    0.93  15,045
                              1.40-1.50    13.75   15.59    1.54    2.11  12,682        94.68    5.56    0.52    1.11  14,702
                              1.50-1.60     3.36   25.57    2.09    2.57  11,077        98.04    6.24    0.57    1.16  14,578
                              1.60-1.70     0.91   33.02    3.50    4.02   9,723        98.95    6.49    0.60    1.18  14,533
                              1.70-1.80     0.24   41.87    5.65    6.17   8,269        99.20    6.58    0.61    1.19  14,518
                              1.80-SINK     0.80   71.82   29.33   31.15   2,360       100.00    7.10    0.84    1.44  14,420
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                                                                                                    USER HANDBOOK EXAMPLE PAGE 61
                                     SUMMARY OF THE PRE-BREAKAGE PERFORMANCE OF UNIT NUMBER    10

                                                          CENTRIFUGE

SIZE, INCHES OR MESH                                6        2       1/2        8M        28M      100M      COMP
                                                   BY       BY        BY        BY         BY        BY
                                                    2      1/2        8M       28M       100M      325M

SCREEN ANALYSIS, PERCENT-
   FEED....................................     34.98    22.89     20.14     10.07      6.19      5.72    100.00
   BROKEN FEED.............................     19.16    25.31     25.03     14.11      9.03      7.35    100.00

ASH, PERCENT
   FEED....................................      6.65     8.01      6.61      6.97      7.58      7.63      7.10
   BROKEN FEED.............................      6.65     7.41      7.00      6.96      7.35      7.52      7.10

PYRITIC SULFUR, PERCENT
   FEED....................................      0.71     0.96      0.49      0.87      1.28      1.88      0.84
   BROKEN FEED.............................      0.71     0.85      0.65      0.76      1.08      1.66      0.84

TOTAL SULFUR, PERCENT
   FEED....................................      1.34     1.56      1.06      1.39      1.85      2.47      1.44
   BROKEN FEED.............................      1.34     1.46      1.23      1.31      1.65      2.24      1.44

BTU/LB, MOISTURE FREE
   FEED.................................... 14,522   14,290    14,549    14,420    14,316    13,970    14,420
   BROKEN FEED............................. 14,522   14,392    14,475    14,450    14,367    14,070    14,420
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                         SUMMARY OF THE PERFORMANCE CHARACTERISTICS OF UNIT NUMBER 18

                                              CENTRIFUGE
                                 UPPER FLOW STREAM = 99.0 PERCENT OF FEED

SIZE, INCHES OR MESH                              6         2       1/2        8M       28M      100M      COMP
                                                 BY        BY        BY        BY        BY        BY
                                                  2       1/2        8M       28M      100M      325M

SCREEN ANALYSIS, PERCENT-
   FEED.................................      34.98     22.89     20.14     10.07      6.19      5.72    100.00
   PRODUCT 1 (UPPER STREAM).................  19.16     25.31     25.03     14.11      9.03      7.35    100.00
   PRODUCT 2 (LOWER STREAM).................  19.16     25.31     25.03     14.11      9.03      7.35    100.00

ASH, PERCENT
   FEED.................................       6.65      8.01      6.61      6.97      7.58      7.63      7.10
   PRODUCT 1 (UPPER STREAM).................   6.65      7.41      7.00      6.96      7.35      7.52      7.10
   PRODUCT 2 (LOWER STREAM).................   6.65      7.41      7.00      6.96      7.35      7.52      7.10

PYRITIC SULFUR, PERCENT
   FEED.................................       0.71      0.96      0.49      0.87      1.28      1.88      0.84
   PRODUCT 1 (UPPER STREAM).................   0.71      0.85      0.65      0.76      1.08      1.66      0.84
   PRODUCT 2 (LOWER STREAM).................   0.71      0.85      0.65      0.76      1.08      1.66      0.84

TOTAL SULFUR, PERCENT
   FEED.................................       1.34      1.56      1.06      1.39      1.85      2.47      1.44
   PRODUCT 1 (UPPER STREAM).................   1.34      1.46      1.23      1.31      1.65      2.24      1.44
   PRODUCT 2 (LOWER STREAM).................   1.34      1.46      1.23      1.31      1.65      2.24      1.44

BTU/LB, MOISTURE FREE
   FEED.................................     14,522    14,290    14,549    14,420    14,316    13,970    14,420
   PRODUCT 1 (UPPER STREAM)................. 14,522    14,392    14,475    14,450    14,367    14,070    14,420
   PRODUCT 2 (LOWER STREAM)................. 14,522    14,392    14,475    14,450    14,367    14,070    14,420
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                                   SPECIFIC GRAVITY ANALYSIS OF FLOWSTREAM NUMBER 28

                             ORIGIN - UNIT NUMBER  18   U        DESTINATION - UNIT NUMBER   0

                                     SPECIFIC              DIRECT, PERCENT                                      CUMULATIVE, PERCENT
     SIZE FRACTION AND WEIGHT        GRAVITY     WEIGHT    ASH  PYRITIC   TOTAL   BTU/LB         WEIGHT    ASH  PYRITIC   TOTAL   BTU/LB
                                                                 SULFUR  SULFUR                                  SULFUR  SULFUR

 6 BY 2                              FLOAT-1.30   44.04    2.83    0.15    0.80  15,355           44.04    2.83    0.15    0.80  15,355
 PERCENT OF FLOW  19.2                1.30-1.35   27.84    4.50    0.64    1.31  14,907           71.87    3.48    0.34    1.00  15,181
                                      1.35-1.40    6.97    8.62    1.13    1.73  13,909           78.84    3.93    0.41    1.06  15,069
                                      1.40-1.50   18.75   15.54    1.74    2.33  12,682           97.59    6.16    0.66    1.30  14,610
                                      1.50-1.60    2.21   25.78    2.24    2.77  11,077           99.80    6.63    0.70    1.34  14,532
                                      1.60-1.70    0.17   32.75    3.63    4.24   9,723           99.97    6.64    0.71    1.34  14,524
                                      1.70-1.80    0.03   42.99    5.76    6.40   8,269          100.00    6.65    0.71    1.34  14,522
                                      1.80-SINK    0.00    0.00    0.00    0.00       0          100.00    6.65    0.71    1.34  14,522

 2 BY 1/2                            FLOAT-1.30   40.69    2.72    0.15    0.79  15,355           40.69    2.72    0.15    0.79  15,355
 PERCENT OF FLOW  25.3                1.30-1.35   29.30    4.59    0.59    1.20  14,907           69.99    3.50    0.33    0.96  15,167
                                      1.35-1.40    8.56    9.09    1.05    1.59  13,909           78.55    4.11    0.41    1.03  15,030
                                      1.40-1.50   16.35   15.73    1.63    2.21  12,682           94.90    6.11    0.62    1.23  14,626
                                      1.50-1.60    3.60   25.95    2.11    2.59  11,077           98.50    6.84    0.68    1.28  14,496
                                      1.60-1.70    0.87   33.72    3.47    4.01   9,723           99.37    7.07    0.70    1.31  14,454
                                      1.70-1.80    0.20   43.01    5.69    6.22   8,269           99.57    7.15    0.71    1.32  14,442
                                      1.80-SINK    0.43   69.61   32.65   35.48   2,841          100.00    7.41    0.85    1.46  14,392

 1/2 BY 8M                           FLOAT-1.30   42.41    2.56    0.12    0.72  15,355           42.41    2.56    0.12    0.72  15,355
 PERCENT OF FLOW  25.0                1.30-1.35   30.33    4.69    0.37    0.96  14,907           72.75    3.45    0.22    0.82  15,168
                                      1.35-1.40    9.44    9.41    0.77    1.27  13,909           82.18    4.13    0.29    0.87  15,024
                                      1.40-1.50   13.00   15.75    1.33    1.88  12,682           95.19    5.72    0.43    1.01  14,704
                                      1.50-1.60    3.41   25.89    1.90    2.35  11,077           98.59    6.42    0.48    1.06  14,578
                                      1.60-1.70    0.77   33.71    3.30    3.75   9,723           99.36    6.63    0.50    1.08  14,541
                                      1.70-1.80    0.18   42.54    5.13    5.55   8,269           99.54    6.69    0.51    1.09  14,530
                                      1.80-SINK    0.46   72.76   31.08   33.25   2,590          100.00    7.00    0.65    1.23  14,475

 8M BY 28M                           FLOAT-1.30   47.49    2.18    0.15    0.69  15,355           47.49    2.18    0.15    0.69  15,355
 PERCENT OF FLOW  14.1                1.30-1.35   26.88    4.57    0.38    0.94  14,907           74.37    3.05    0.24    0.78  15,193
                                      1.35-1.40    8.24    9.26    0.80    1.30  13,909           82.61    3.67    0.29    0.83  15,065
                                      1.40-1.50   10.80   15.67    1.37    1.92  12,682           93.41    5.05    0.42    0.96  14,789
                                      1.50-1.60    4.18   25.68    2.04    2.51  11,077           97.59    5.94    0.49    1.03  14,630
                                      1.60-1.70    1.33   33.28    3.46    4.00   9,723           98.92    6.30    0.53    1.07  14,565
                                      1.70-1.80    0.29   42.60    5.52    6.01   8,269           99.21    6.41    0.54    1.08  14,546
                                      1.80-SINK    0.79   75.64   28.20   29.92   2,330          100.00    6.96    0.76    1.31  14,450

 28M BY 100M                         FLOAT-1.30   54.90    1.97    0.16    0.71  15,355           54.90    1.97    0.16    0.71  15,355
 PERCENT OF FLOW   9.0                1.30-1.35   20.39    5.12    0.48    1.02  14,907           75.29    2.83    0.24    0.80  15,234
                                      1.35-1.40    8.35    8.81    0.90    1.39  13,909           83.64    3.42    0.31    0.85  15,101
                                      1.40-1.50    8.05   15.62    1.53    2.09  12,682           91.69    4.49    0.42    0.96  14,889
                                      1.50-1.60    3.94   25.24    2.27    2.75  11,077           95.63    5.35    0.49    1.04  14,732
                                      1.60-1.70    1.89   32.61    3.63    4.19   9,723           97.52    5.88    0.55    1.10  14,635
                                      1.70-1.80    0.65   41.51    5.73    6.29   8,269           98.17    6.11    0.59    1.13  14,593
                                      1.80-SINK    1.83   73.71   27.70   29.35   2,282          100.00    7.35    1.08    1.65  14,367
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                                                                                                    USER HANDBOOK EXAMPLE PAGE 64

                                   SPECIFIC GRAVITY ANALYSIS OF FLOWSTREAM NUMBER 28 (CONTINUED)

                             ORIGIN - UNIT NUMBER  18   U       DESTINATION - UNIT NUMBER   0

                                                                                                 CUMULATIVE, PERCENT
                                   SPECIFIC            DIRECT, PERCENT                                 ASH  PYRITIC   TOTAL   BTU/LB
     SIZE FRACTION AND WEIGHT      GRAVITY    WEIGHT    ASH  PYRITIC   TOTAL  BTU/LB     .WEIGHT             SULFUR   SULFUR
                                                             SULFUR    SULFUR

 100M BY 325M                     FLOAT-1.30   46.25    1.59   0.13    0.67  15,355      46.25   1.59    0.13     0.67  15,355
 PERCENT OF FLOW   7.3             1.30-1.35   24.42    3.55   0.34    0.90  14,907      70.67   2.27    0.20     0.75  15,200
                                   1.35-1.40   13.18    5.46   0.54    1.11  13,909      83.85   2.77    0.26     0.81  14,997
                                   1.40-1.50    6.91   13.52   1.34    1.88  12,682      90.77   3.59    0.34     0.89  14,821
                                   1.50-1.60    3.06   22.70   2.28    2.80  11,077      93.83   4.21    0.40     0.95  14,699
                                   1.60-1.70    1.46   30.60   3.72    4.20   9,723      95.29   4.62    0.45     1.00  14,623
                                   1.70-1.80    0.57   39.44   6.14    6.71   8,269      95.86   4.82    0.49     1.03  14,585
                                   1.80-SINK    4.14   69.83  28.78   30.24   2,155     100.00   7.52    1.66     2.24  14,070

 COMPOSITE                        FLOAT-1.30   44.41    2.45   0.14    0.74  15,355      44.41   2.45    0.14     0.74  15,355
 FLOWRATE          277.8           1.30-1.35   27.77    4.57   0.49    1.09  14,907      72.19   3.26    0.28     0.88  15,183
                                   1.35-1.40    8.75    8.70   0.88    1.42  13,909      80.94   3.85    0.34     0.93  15,045
                                   1.40-1.50   13.75   15.59   1.54    2.11  12,682      94.68   5.56    0.52     1.11  14,702
                                   1.50-1.60    3.36   25.57   2.09    2.57  11,077      98.04   6.24    0.57     1.16  14,578
                                   1.60-1.70    0.91   33.02   3.50    4.02   9,723      98.95   6.49    0.60     1.18  14,533
                                   1.70-1.80    0.24   41.87   5.65    6.17   8,269      99.20   6.58    0.61     1.19  14,518
                                   1.80-SINK    0.80   71.82  29.33   31.15   2,360     100.00   7.10    0.84     1.44  14,420
                                   SPECIFIC GRAVITY ANALYSIS OF FLOWSTREAM NUMBER 29

                         ORIGIN - UNIT NUMBER  18    L        DESTINATION - UNIT NUMBER   2

                                 SPECIFIC              DIRECT, PERCENT                                    CUMULATIVE, PERCENT
     SIZE FRACTION AND WEIGHT    GRAVITY     WEIGHT    ASH  PYRITIC   TOTAL  BTU/LB      WEIGHT    ASH  PYRITIC   TOTAL  BTU/LB
                                                                SULFUR  SULFUR                              SULFUR  SULFUR

  6 BY 2                        FLOAT-1.30   44.04     2.83    0.15    0.80  15,355       44.04    2.83    0.15    0.80  15,355
  PERCENT OF FLOW  19.2          1.30-1.35   27.64     4.50    0.64    1.31  14,907       71.87    3.48    0.34    1.00  15,181
                                 1.35-1.40    6.97     8.62    1.13    1.73  13,909       78.84    3.93    0.41    1.06  15,069
                                 1.40-1.50   18.75    15.54    1.74    2.33  12,682       97.59    6.16    0.66    1.30  14,610
                                 1.50-1.60    2.21    25.78    2.24    2.77  11,077       99.80    6.60    0.70    1.34  14,532
                                 1.60-1.70    0.17    32.75    3.63    4.24   9,723       99.97    6.64    0.71    1.34  14,524
                                 1.70-1.80    0.03    42.99    5.76    6.40   8,269      100.00    6.65    0.71    1.34  14,522
                                 1.80-SINK    0.00     0.00    0.00    0.00       0      100.00    6.65    0.71    1.34  14,522

  2 BY 1/2                      FLOAT-1.30   40.69     2.72    0.15    0.79  15,355       40.69    2.72    0.15    0.79  15,355
  PERCENT OF FLOW  25.3          1.30-1.35   29.30     4.59    0.59    1.20  14,907       69.99    3.50    0.33    0.96  15,167
                                 1.35-1.40    8.56     9.09    1.05    1.59  13,909       78.55    4.11    0.41    1.03  15,030
                                 1.40-1.50   16.35    15.73    1.63    2.21  12,682       94.90    6.11    0.62    1.23  14,626
                                 1.50-1.60    3.60    25.95    2.11    2.59  11,077       98.50    6.84    0.68    1.28  14,496
                                 1.60-1.70    0.87    33.72    3.47    4.01   9,723       99.37    7.07    0.70    1.31  14,454
                                 1.70-1.80    0.20    43.01    5.69    6.22   8,269       99.57    7.15    0.71    1.32  14,442
                                 1.80-SINK    0.43    69.61   32.65   35.48   2,841      100.00    7.41    0.85    1.46  14,392

  1/2 BY 8M                     FLOAT-1.30   42.41     2.56    0.12    0.72  15,355       42.41    2.56    0.12    0.72  15,355
  PERCENT OF FLOW  25.0          1.30-1.35   30.33     4.69    0.37    0.96  14,907       72.75    3.45    0.22    0.82  15,168
                                 1.35-1.40    9.44     9.41    0.77    1.27  13,909       82.18    4.13    0.29    0.87  15,024
                                 1.40-1.50   13.00    15.75    1.33    1.88  12,682       95.19    5.72    0.43    1.01  14,704
                                 1.50-1.60    3.41    25.89    1.90    2.35  11,077       98.59    6.42    0.48    1.06  14,578
                                 1.60-1.70    0.77    33.71    3.30    3.75   9,723       99.36    6.63    0.50    1.08  14,541
                                 1.70-1.80    0.18    42.54    5.13    5.55   8,269       99.54    6.69    0.51    1.09  14,530
                                 1.80-SINK    0.46    72.76   31.08   33.25   2,590      100.00    7.00    0.65    1.23  14,475

  8M BY 28M                     FLOAT-1.30   47.49     2.18    0.15    0.69  15,355       47.49    2.18    0.15    0.69  15,355
  PERCENT OF FLOW  14.1          1.30-1.35   26.88     4.57    0.38    0.94  14,907       74.37    3.05    0.24    0.78  15,193
                                 1.35-1.40    8.24     9.26    0.80    1.30  13,909       82.61    3.67    0.29    0.83  15,065
                                 1.40-1.50   10.80    15.67    1.37    1.92  12,682       93.41    5.05    0.42    0.96  14,789
                                 1.50-1.60    4.18    25.68    2.04    2.51  11,077       97.59    5.94    0.49    1.03  14,630
                                 1.60-1.70    1.33    33.28    3.46    4.00   9,723       98.92    6.30    0.53    1.07  14,565
                                 1.70-1.80    0.29    42.60    5.52    6.01   8,269       99.21    6.41    0.54    1.08  14,546
                                 1.80-SINK    0.79    75.64   28.20   29.92   2,330      100.00    6.96    0.76    1.31  14,450

  28M BY 100M                   FLOAT-1.30   54.90     1.97    0.16    0.71  15,355       54.90    1.97    0.16    0.71  15,355
  PERCENT OF FLOW   9.0          1.30-1.35   20.39     5.12    0.48    1.02  14,907       75.29    2.83    0.24    0.80  15,234
                                 1.35-1.40    8.35     8.81    0.90    1.39  13,909       83.64    3.42    0.31    0.85  15,101
                                 1.40-1.50    8.05    15.62    1.53    2.09  12,682       91.69    4.49    0.42    0.96  14,889
                                 1.50-1.60    3.94    25.24    2.27    2.75  11,077       95.63    5.35    0.49    1.04  14,732
                                 1.60-1.70    1.89    32.61    3.63    4.19   9,723       97.52    5.88    0.55    1.10  14,635
                                 1.70-1.80    0.65    41.51    5.73    6.29   8,269       98.17    6.11    0.59    1.13  14,593
                                 1.80-SINK    1.83    73.71   27.70   29.35   2,282      100.00    7.35    1.08    1.65  14,367
```

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                              SPECIFIC GRAVITY ANALYSIS OF FLOWSTREAM NUMBER 29 (CONTINUED)

                          ORIGIN - UNIT NUMBER  18   L        DESTINATION - UNIT NUMBER   2

                                  SPECIFIC             DIRECT, PERCENT                                  CUMULATIVE, PERCENT
    SIZE FRACTION AND WEIGHT      GRAVITY     WEIGHT    ASH  PYRITIC   TOTAL   BTU/LB        WEIGHT   ASH  PYRITIC   TOTAL   BTU/LB
                                                             SULFUR  SULFUR                                SULFUR  SULFUR

  100M BY 325M                   FLOAT-1.30   46.25    1.59    0.13    0.67  15,355         46.25   1.59    0.13    0.67  15,355
  PERCENT OF FLOW   7.3           1.30-1.35   24.42    3.55    0.34    0.90  14,907         70.67   2.27    0.20    0.75  15,200
                                  1.35-1.40   13.18    5.46    0.54    1.11  13,909         83.85   2.77    0.26    0.81  14,997
                                  1.40-1.50    6.91   13.52    1.34    1.88  12,682         90.77   3.59    0.34    0.89  14,821
                                  1.50-1.60    3.06   22.70    2.28    2.80  11,077         93.83   4.21    0.40    0.95  14,699
                                  1.60-1.70    1.46   30.60    3.72    4.20   9,723         95.29   4.62    0.45    1.00  14,623
                                  1.70-1.80    0.57   39.44    6.14    6.71   8,269         95.86   4.82    0.49    1.03  14,585
                                  1.80-SINK    4.14   69.83   28.78   30.24   2,155        100.00   7.52    1.66    2.24  14,070

  COMPCSITE                      FLOAT-1.30   44.41    2.45    0.14    0.74  15,355         44.41   2.45    0.14    0.74  15,355
  FLOWRATE            2.8         1.30-1.35   27.77    4.57    0.49    1.09  14,907         72.19   3.26    0.28    0.88  15,183
                                  1.35-1.40    8.75    8.70    0.88    1.42  13,909         80.94   3.85    0.34    0.93  15,045
                                  1.40-1.50   13.75   15.59    1.54    2.11  12,682         94.68   5.56    0.52    1.11  14,702
                                  1.50-1.60    3.36   25.57    2.09    2.57  11,077         98.04   6.24    0.57    1.16  14,578
                                  1.60-1.70    0.91   33.02    3.50    4.02   9,723         98.95   6.49    0.60    1.18  14,533
                                  1.70-1.80    0.24   41.87    5.65    6.17   8,269         99.20   6.58    0.61    1.19  14,518
                                  1.80-SINK    0.80   71.82   29.33   31.15   2,360        100.00   7.10    0.84    1.44  14,420
```

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                                                                                          USER HANDBOOK EXAMPLE PAGE 67
                                      SUMMARY DATA FOR UNITS

UNIT NUMBER        UNIT TYPE                          DECISION VARIABLES             YIELD      BTU RECOVERY   WATER ADDED
-----------        ---------                          ------------------           (PERCENT)     (PERCENT)         GPM
                                                                                   ---------   ------------   -----------

     1        11 (ROTARY BREAKER)                    20.000   12.000    6.000
     2        41 (BLENDER (ADDS WATER))              67.500                                                        71.4
     3        23 (WET UPPER SCREEN)                   1.500   15.000
     4        24 (WET LOWER SCREEN)                   0.500   15.000
     5        41 (STREAM BLENOFR)
     6         6 (TWO-STAGE BAUM JIG)                 1.620                           56.1          84.7
     7        41 (STREAM BLENDER)
     8        16 (SECONDARY MULTIPLE ROLL CRUSHER)    0.275
     9        41 (STREAM BLENDER)
    10        23 (WET SINGLE DECK SCREEN)             0.023   15.000
    11         1 (CONCENTRATING TABLE)                1.580                           60.7          85.7
    12        41 (STREAM BLENDER)
    13         7 (FROTH FLOTATION CELL)              20.000                           65.7          86.6
    14        41 (STREAM BLENDER)
    15        52 (CENTRIFUGE)                        99.000    4.000
    16        41 (STREAM BLENDER)
    17        41 (STREAM BLENDER)
    18        52 (CENTRIFUGE)                        99.000    3.000
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                                                                                              USER HANDBOOK EXAMPLE PAGE 68

                                              SUMMARY DATA FOR FLOWSTREAMS

                                                          ASH     PYRITIC     TOTAL      BTU/LB
 FLOWSTREAM   ORIGIN   DESTINATION   FLOWRATE                  SULFUR     SULFUR                 LBS SO2/     MOISTURE    WATER
   NUMBER    UNIT NO.   UNIT NO.       TPH     (PERCENT)  (PERCENT)  (PERCENT)              MILLION BTU   (PERCENT)    GPM
 ----------  --------  -----------   --------  ---------  ---------  ---------  ---------   -----------   ---------   ------

      1         0           1          500.0      38.40       8.06       8.86      9,145        19.37         0.00       0.0
      2         1  C        2          433.5      29.68       9.17      10.07     10,442        19.29         0.00       0.0
      3         2           3          438.6      29.78       9.16      10.06     10,427        19.29        67.50   3,643.5
      4         1  R        7           66.5      95.28       0.84       0.92        688        26.61         0.00       0.0
      5         3  U        5          229.9      37.43      10.91      11.85      9,185        25.80        15.00     162.3
      6         3  L        4          208.6      21.35       7.22       8.09     11,795        13.71        80.66   3,481.2
      7         4  U        5           66.4      26.70      10.01      11.22     10,836        20.70        15.00      46.9
      8         4  L        9          142.3      18.85       5.91       6.63     12,243        10.83        85.79   3,434.3
      9         5  U        6          296.3      35.02      10.71      11.71      9,555        24.50        15.00     209.2
     10         6  C       17          166.2       7.24       0.82       1.44     14,421         2.00        15.00     117.3
     11         6  M        8           44.9      66.19      21.64      23.06      4,059       113.65        15.00      31.7
     12         6  R        7           85.2      72.80      24.25      25.74      2,958       174.04        15.00      60.2
     13         7  R       12          151.7      82.65      13.99      14.86      1,963       151.40         9.02      60.2
     14         8  M        9           44.9      66.19      21.64      23.06      4,059       113.65        15.00      31.7
     15         9  M       10          187.1      30.20       9.66      10.57     10,280        20.57        82.24   3,466.0
     16        10  U       11          169.7      30.88       9.85      10.75     10,193        21.09        15.00     119.8
     17        10  L       13           17.4      23.62       8.02       8.83     11,128        15.88        97.96   3,346.2
     18        11  C       16          103.0       7.14       0.89       1.45     14,391         2.01        15.00      72.7
     19        11  R       12           66.7      67.51      23.69      25.10      3,713       135.23        15.00      47.1
     20        12  R       14          218.4      78.03      16.95      17.99      2,498       144.05        10.93     107.3
     21        13  C       16           11.4       4.70       0.64       1.20     14,655         1.63        20.00      11.4
     22        13  R       14            6.0      59.95      22.18      23.49      4,355       107.87        99.29   3,334.7
     23        14  R       15          224.4      77.55      17.09      18.14      2,547       142.41        79.32   3,442.0
```

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                                                                                          USER HANDBOOK EXAMPLE PAGE 69
                                           SUMMARY DATA FOR FLOWSTREAMS
                                                  ASH      PYRITIC     TOTAL      BTU/LB
 FLOWSTREAM  ORIGIN   DESTINATION  FLOWRATE               SULFUR      SULFUR                  LBS SO2/     MOISTURE   WATER
   NUMBER   UNIT NO.   UNIT NO.      TPH     (PERCENT)  (PERCENT)   (PERCENT)              MILLION BTU   (PERCENT)    GPM
 ---------- --------  -----------  --------  ---------  ---------   ---------   ---------  -----------   ---------  ------

     24      15   U        0         222.2     77.55      17.09       18.14       2,547      142.41         4.00      37.0

     25      15   L        2           2.2     77.55      17.09       18.14       2,547      142.41        99.74   3,405.0

     26      16   C       17         114.4      6.90       0.86        1.42      14,418        1.97        15.53      84.1

     27      17   C       18         280.7      7.10       0.84        1.44      14,420        1.99        15.22     201.5

     28      18   U        0         277.8      7.10       0.84        1.44      14,420        1.99         3.00      34.4

     29      18   L        2           2.8      7.10       0.84        1.44      14,420        1.99        93.70     167.1

 *     THIS SIMULATION REQUIRED 6,271 CELLS OF WORKING STORAGE
```

APPENDIX B

USER HANDBOOK COST EXAMPLE

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                                                                        USER HANDBOOK COST EXAMPLE PAGE 1
UNIT NUMBER                UNIT TYPE                    DECISION VARIABLES
     1                   21 (SCALPING SCREEN)                   6.000
     2                   41 (BLENDER)
     3                    5 (8 CELL BAUM JIG)                   1.600
     4                   23 (SCREEN)                            0.750
     5                   14 (CRUSHER)                           1.176
     6                   24 (SCREEN)                            0.250
     7                   41 (SUMP (BLENDER))
     8                    3 (CLASSIFYING CYCLONE)               1.500
     9                   23 (SCREEN)                            0.001
    10                   41 (CENTRIFUGE (BLENDER))
    11                   41 (BLENDER)
    12                   41 (BLENDER)
    13                   41 (SUMP (BLENDER))
    14                    4 (HYDROCYCLONE)                      1.500
    15                   23 (SCREEN)                            0.001
    16                   41 (CENTRIFUGE (BLENDER))
    17                   41 (BLENDER)
    18                   51 (SPLITTER)                         33.330
    19                   41 (SUMP (BLENDER))
    20                   23 (REFUSE SCREEN)                     0.019
```

```
                                                                                       USER HANDBOOK COST EXAMPLE PAGE 2
FLOWSTREAM NUMBER               ORIGIN - UNIT NUMBER                DESTINATION - UNIT NUMBER
      1  (FEED)                        0                                    1
      2                                1  U                                 0
      3                                1  L                                 2
      4                                2                                    3
      5                                3  R                                20
      6                                3  C                                 4
      7                                4  U                                 5
      8                                4  L                                 6
      9                                5                                   11
     10                                6  U                                11
     11                                6  L                                 7
     12                                7                                    8
     13                                8  R                                12
     14                                8  C                                 9
     15                                9  L                                12
     16                                9  U                                10
     17                               10                                   11
     18                               11                                   17
     19                               12                                   13
     20                               13                                   14
     21                               14  R                                18
     22                               14  C                                15
     23                               15  L                                12
     24                               15  U                                16
     25                               16                                   17
     26  (CLEAN COAL PRODUCT)         17  C                                 0
```

```
                                                                                  USER HANDBOOK COST EXAMPLE PAGE 3
    FLOWSTREAM NUMBER                    ORIGIN - UNIT NUMBER                    DESTINATION - UNIT NUMBER
           27                                        18    L                                0
           28                                        18    U                               19
           29                                        19                                     2
           30                                        20    U                                0
           31                                        20    L                                0
```

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                                                                                                       USER HANDBOOK COST EXAMPLE PAGE 4

                                               SPECIFIC GRAVITY ANALYSIS OF FLOWSTREAM NUMBER 1

FEED TO UNIT NUMBER 1
                                                                                                          CUMULATIVE, PERCENT
                                          SPECIFIC              DIRECT, PERCENT                                         
      SIZE FRACTION AND WEIGHT            GRAVITY     WEIGHT      ASH   TOTAL    BTU/LB        WEIGHT      ASH   TOTAL   BTU/LB
                                                                        SULFUR                                  SULFUR

                                          FLOAT-1.40   46.42     4.75    0.78  14,003         46.42     4.75    0.78  14,003
   6 BY 3/4                                1.40-1.45    2.67    13.33    0.76  12,352         49.09     5.22    0.78  13,913
   PERCENT OF FLOW  29.7                   1.45-1.50    1.22    23.63    0.93  10,990         50.31     5.66    0.78  13,842
                                           1.50-1.55    1.06    29.59    0.51   9,880         51.37     6.16    0.78  13,761
                                           1.55-1.60    1.55    55.96    0.42   5,263         52.92     7.61    0.77  13,512
                                           1.60-SINK   47.08    78.89    0.41   2,060        100.00    41.17    0.60   8,120

                                          FLOAT-1.40   47.23     4.69    0.78  13,810         47.23     4.69    0.78  13,810
   3/4 BY 0                                1.40-1.45    4.49    14.67    0.80  11,737         51.72     5.56    0.78  13,630
   PERCENT OF FLOW  70.2                   1.45-1.50    3.00    16.61    0.94  10,219         54.72     6.16    0.79  13,443
                                           1.50-1.55    2.04    21.69    0.87   9,712         56.76     6.72    0.79  13,309
                                           1.55-1.60    1.99    35.99    0.76   7,707         58.75     7.71    0.79  13,119
                                           1.60-SINK   41.25    74.68    0.47   2,388        100.00    35.34    0.65   8,693

   COMPOSITE                              FLOAT-1.40   46.99     4.71    0.78  13,867         46.99     4.71    0.78  13,867
   FLOWRATE              600.0             1.40-1.45    3.95    14.40    0.79  11,861         50.94     5.46    0.78  13,711
                                           1.45-1.50    2.47    17.64    0.94  10,332         53.41     6.02    0.79  13,555
                                           1.50-1.55    1.75    23.10    0.81   9,742         55.16     6.56    0.79  13,434
                                           1.55-1.60    1.86    40.94    0.68   7,101         57.02     7.68    0.79  13,228
                                           1.60-SINK   42.98    76.05    0.45   2,281        100.00    37.07    0.64   8,522
```

```
                                                                                          USER HANDBOOK COST EXAMPLE PAGE 5
                                              SUMMARY DATA FOR UNITS

UNIT NUMBER        UNIT TYPE                             DECISION VARIABLES           YIELD      BTU RECOVERY    WATER ADDED
                                                                                    (PERCENT)     (PERCENT)          GPM
-----------        ---------                             ------------------         ---------    ------------    -----------

      1       21 (SCALPING SCREEN)                             6.000
      2       41 (BLENDER)
      3        5 (8 CELL BAUM JIG)                             1.600                   63.2          88.0
      4       23 (SCREEN)                                      0.750
      5       14 (CRUSHER)                                     1.176
      6       24 (SCREEN)                                      0.250
      7       41 (SUMP (BLENDER))
      8        3 (CLASSIFYING CYCLONE)                         1.500                   76.7          91.8
      9       23 (SCREEN)                                      0.001
     10       41 (CENTRIFUGE (BLENDER))
     11       41 (BLENDER)
     12       41 (BLENDER)
     13       41 (SUMP (BLENDER))
     14        4 (HYDROCYCLONE)                                1.500                    4.3           6.6
     15       23 (SCREEN)                                      0.001
     16       41 (CENTRIFUGE (BLENDER))
     17       41 (BLENDER)
     18       51 (SPLITTER)                                   33.330
     19       41 (SUMP (BLENDER))
     20       23 (REFUSE SCREEN)                               0.019
```

SUMMARY DATA FOR FLOWSTREAMS

FLOWSTREAM NUMBER	ORIGIN UNIT NO.		DESTINATION UNIT NO.	FLOWRATE TPH	ASH (PERCENT)	TOTAL SULFUR (PERCENT)	BTU/LB	LBS SO2/ MILLION BTU	MOISTURE (PERCENT)	WATER GPM
1	0		1	600.0	37.07	0.64	8,522	1.50	0.00	0.0
2	1	U	0	0.0	41.17	0.60	8,120	1.47	0.00	0.0
3	1	L	2	600.0	37.07	0.64	8,522	1.50	0.00	0.0
4	2		3	606.4	37.35	0.64	8,473	1.51	0.00	0.0
5	3	R	20	223.3	73.03	0.47	2,754	3.38	0.00	0.0
6	3	C	4	383.0	16.56	0.74	11,608	1.26	0.00	0.0
7	4	U	5	95.4	7.83	0.77	13,476	1.14	0.00	0.0
8	4	L	6	287.6	19.45	0.73	11,254	1.30	0.00	0.0
9	5		11	95.4	7.83	0.77	13,476	1.14	0.00	0.0
10	6	U	11	201.9	19.45	0.73	11,254	1.30	0.00	0.0
11	6	L	7	85.8	19.45	0.73	11,254	1.30	0.00	0.0
12	7		8	85.8	19.45	0.73	11,254	1.30	0.00	0.0
13	8	R	12	20.0	63.28	0.56	3,969	2.80	0.00	0.0
14	8	C	9	65.8	6.12	0.79	13,470	1.17	0.00	0.0
15	9	L	12	0.0	6.12	0.79	13,470	1.17	0.00	0.0
16	9	U	10	65.7	6.12	0.79	13,470	1.17	0.00	0.0
17	10		11	65.7	6.12	0.79	13,470	1.17	0.00	0.0
18	11		17	363.0	13.98	0.75	12,240	1.23	0.00	0.0
19	12		13	20.0	63.22	0.56	3,979	2.79	0.00	0.0
20	13		14	20.0	63.22	0.56	3,979	2.79	0.00	0.0
21	14	R	18	19.2	63.89	0.55	3,883	2.84	0.00	0.0
22	14	C	15	0.9	48.24	0.66	6,114	2.16	0.00	0.0
23	15	L	12	0.0	48.24	0.66	6,114	2.16	0.00	0.0

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                                                                                              USER HANDBOOK COST EXAMPLE PAGE 7
                                                         SUMMARY DATA FOR FLOWSTREAMS
                                                               ASH        TOTAL      BTU/LB
 FLOWSTREAM   ORIGIN    DESTINATION    FLOWRATE                   SULFUR                  LBS SO2/      MOISTURE    WATER
   NUMBER    UNIT NO.    UNIT NO.        TPH       (PERCENT)   (PERCENT)              MILLION BTU    (PERCENT)    GPM
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     24       13   U        16            0.9        48.24        0.66       5,114         2.16          0.00        0.0
     25       16            17            0.9        48.24        0.66       5,114         2.16          0.00        0.0
     26       17   C         0          363.9        14.06        0.75      12,225         1.23          0.00        0.0
     27       18   L         0           12.6        63.89        0.55       3,063         2.84          0.00        0.0
     28       18   U        19            6.4        63.89        0.55       3,083         2.84          0.00        0.0
     29       19             2            6.4        63.89        0.55       3,083         2.84          0.00        0.0
     30       20   U         0          222.2        73.04        0.47       2,753         3.38          0.00        0.0
     31       20   L         0            1.1        70.55        0.50       3,003         3.30          0.00        0.0
*    THIS SIMULATION REQUIRED 1,796 CELLS OF WORKING STORAGE
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                                                                      USER HANDBOOK COST EXAMPLE PAGE 8

LISTING OF COST ELEMENT VALUES FOR USER HANDBOOK COST EXAMPLE

TOTAL PREPARATION PLANT EQUIPMENT COST.........        512,895.75
 6*16 FT SINGLE DECK SCALPING SCREEN...........         17,500.00
 EIGHT CELL BAUM TYPE JIG......................        175,987.99
 6*16 FT DOUBLE DECK DEWATERING SCREENS........         45,993.41
 5*10 FT DOUBLE DECK REFUSE SCREEN.............         18,001.09
 CRUSHER.......................................         12,102.98
 CLASSIFYING CYCLONE 20 INCH DIAM NIHARD.......          9,596.51
 HYDROCYCLONE 14 INCH DIAM RUBBER LINED........          6,508.33
 3*12 FT SINGLE DECK DESLIMING SCREEN..........         11,507.07
 CENTRIFUGAL DRYER.............................         22,239.87
 CENTRIFUGAL DRYERS............................         56,437.32
 6*16 FT SINGLE DECK DESLIMING SCREEN..........         31,982.76
 SUMP..........................................         30,038.44
 PUMPS.........................................         74,993.96
TOTAL CAPITAL REQUIREMENT......................      3,940,630.34
 TOTAL COST OF PREPARATION PLANT...............      1,538,687.25
 RAW COAL STORAGE AND HANDLING.................        424,000.00
  RAW COAL STORAGE AREA...20000 TON CAPAC......        300,000.00
  RAW COAL BELT TO PLANT...42 INCH WIDE........        104,000.00
  TRAMP IRON MAGNET............................         20,000.00
 OTHER FACILITIES AND EQUIPMENT................      1,464,000.00
  CLEAN COAL BELT....36 INCH WIDE..............        144,000.00
  CLEAN COAL STORAGE AREA...40000 TON..........        350,000.00
  REFUSE BELT 36 INCH WIDE.....................        120,000.00
  REFUSE BIN...................................         50,000.00
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                                                            USER HANDBOOK COST EXAMPLE PAGE 9

LISTING OF COST ELEMENT VALUES FOR USER HANDBOOK COST EXAMPLE

  RAW COAL AND REFUSE HANDLING EQUIPMENT.........      300,000.00
  UNIT-TRAIN LOADING FACILITY....................      500,000.00
CONTINGENCY......................................      514,003.09
  PREPARATION PLANT CONTINGENCY..................      230,803.09
  RAW COAL STORAGE CONTINGENCY...................       63,600.00
  OTHER FACILITIES CONTINGENCY...................      219,600.00
OPERATING AND MAINTENANCE COST...................    2,479,822.80
 LABOR - SUPERVISORY (NON-UNION).................       68,640.00
 LABOR - OPERATING + MAINTENANCE (UNION).........      472,680.00
 FRINGE BENEFITS - NON-UNION.....................       17,160.00
 FRINGE BENEFITS - UNION.........................       99,262.80
 OTHER OVERHEAD..................................       92,040.00
 OPERATING SUPPLIES..............................      241,800.00
 OPERATING MAINTENANCE...........................      230,880.00
 MAJOR MAINTENANCE...............................      209,040.00
 ELECTRICITY.....................................      113,880.00
 SUBCONTRACT SERVICES............................      934,440.00
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                                                                                    USER HANDBOOK COST EXAMPLE PAGE 10

                                   PROJECT CASH FLOW DESCRIPTION FOR USER HANDBOOK COST EXAMPLE

                             DEPRECIABLE      NONDEPRECIABLE
             ANNUAL            CAPITAL          OPERATING                                            OTHER TAX
  YEAR     PRODUCTION         INVESTMENT        INVESTMENT        EXPENSES       DEPRECIATION       ALLOWANCES
    0          0.00          3940690.34            0.00              0.00             0.00              0.00
    1     946094.49                0.00            0.00        2479822.80        394069.03              0.00
    2     946094.49                0.00            0.00        2479822.80        394069.03              0.00
    3     946094.49                0.00            0.00        2479822.80        394069.03              0.00
    4     946094.49                0.00            0.00        2479822.80        394069.03              0.00
    5     946094.49                0.00            0.00        2479822.80        394069.03              0.00
    6     946094.49                0.00            0.00        2479822.80        394069.03              0.00
    7     946094.49                0.00            0.00        2479822.80        394069.03              0.00
    8     946094.49                0.00            0.00        2479822.80        394069.03              0.00
    9     946094.49                0.00            0.00        2479822.80        394069.03              0.00
   10     946094.49                0.00            0.00        2479822.80        394069.03              0.00
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                         DISCOUNTED CASH FLOW ANALYSIS FOR USER HANDBOOK COST EXAMPLE

                                             CASH FLOW
              TAXABLE           TAXES          AFTER           NET             DISCOUNT       DISCOUNTED
YEAR           INCOME            PAID          TAXES         CASH FLOW          FACTOR         CASH FLOW
  0              0.00            0.00           0.00       -3940690.34         1.090000     -4295352.4657
  1         439939.38       219969.69      614038.72         614038.72         1.000000       614038.7224
  2         439939.38       219969.69      614038.72         614038.72          .917431       563338.2774
  3         439939.38       219969.69      614038.72         614038.72          .841680       516824.1077
  4         439939.38       219969.69      614038.72         614038.72          .772183       474150.5575
  5         439939.38       219969.69      614038.72         614038.72          .708425       435000.5115
  6         439939.38       219969.69      614038.72         614038.72          .649931       399083.0381
  7         439939.38       219969.69      614038.72         614038.72          .596267       366131.2276
  8         439939.38       219969.69      614038.72         614038.72          .547034       335900.2088
  9         439939.38       219969.69      614038.72         614038.72          .501866       308165.3292
 10         439939.38       219969.69      614038.72         614038.72          .460428       282720.4855

UNIT SELLING PRICE     3.5026 RATE OF RETURN= .0900 INCOME TAX RATE= .5000
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